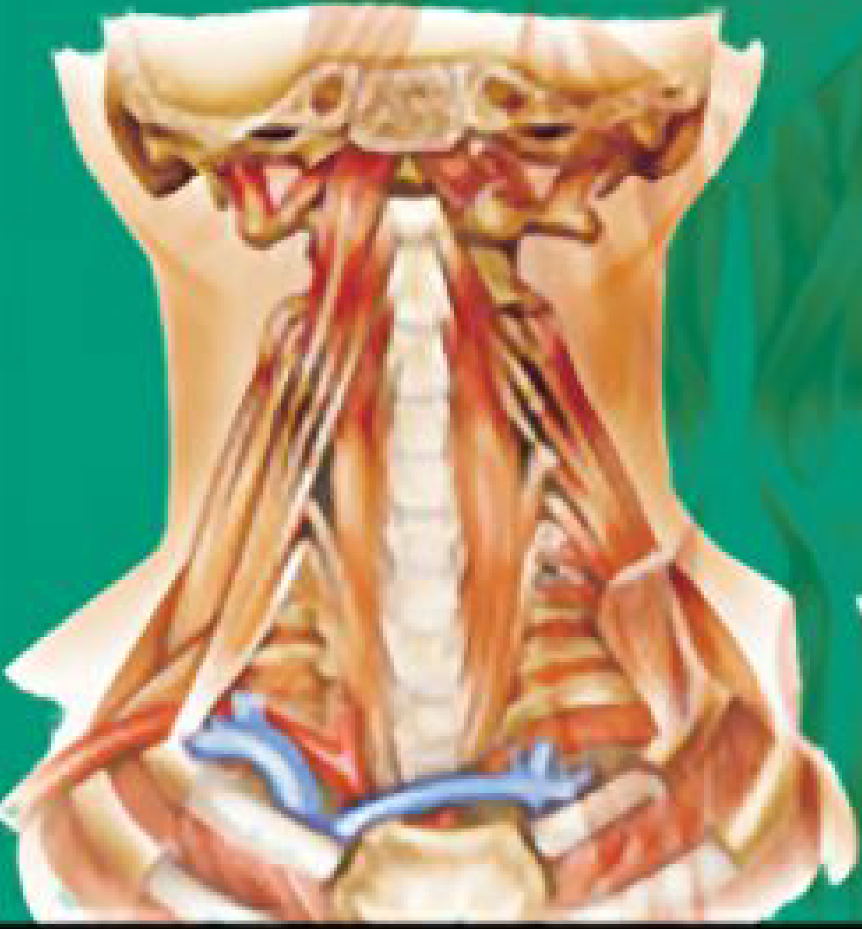
Volume 3

Kadasne's

# Textbook of ANATOMY

(Clinically Oriented)

Head, Neck, Face & Brain



DK Kadasne

Foreword

Vedprakash Mishra

JAYPEE

*Kadasne's*

Textbook of

# ANATOMY

*(Clinically Oriented)*

# *Kadasne's* Textbook of ANATOMY *(Clinically Oriented)*

## Volume 3: Head, Neck, Face and Brain

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***Kadasne’s Textbook of Anatomy (Clinically Oriented) (Volume 3)***



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*Dedicated to*
*the Sacred Memory*
*of*
*My Late Beloved*
*Parents*


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# FOREWORD

Peeping into memory lanes of the yester years, it vividly comes into my focused attention of the Herculean difficulties which I had to face as an ordinary student of first MBBS in the early 70's, while groping into the annals of Anatomy as a subject. It appeared to be "tough, baffling and difficult to grasp", and much more, difficult to 'retain' for the purposes of 'recall'.

Frankly speaking, it was genuinely a dreadful proposition till we were told by our seniors to just fall back to the notes titled' Approach to Anatomy' penned by none else than respected Dr DK Kadasane Sir. It realistically had an astonishing effect to the extent that what was 'dreadful; till the previous day became understandingly lovable subsequent thereto. It was some sort of realistic magic which till date does not go out of the memory.

I therefore feel greatly privileged to be writing this foreword for the present book, which is a genuine manifestation of unparalleled creativity brought out by respected Dr DK Kadasane Sir in his lucid and free flowing style. The contents, description, syntaxing and diagrammatic depiction, all taken together make it look as if it is "Anatomy made easiest" for one and all.

Indeed, it is a great venture which is nothing but a depiction of the commitment that Dr DK Kadasane Sir has harboured deep in his heart and mind for the subject of anatomy all his life and has never fallen short when he started writting the book which would cater to the cause of the learners as well as teachers in a meaningful way.

No amount of praise showered on him would be sufficient to commensurate with his single minded devotion to the teaching and learning of the subject of anatomy and facilitating it in a way which would really be memorable on all counts.

I have every reason to believe that this book entitled *Kadasne's Textbook of Anatomy (Clinically Oriented)* would not only be handy, useful, purposive and relevant to the requirements of students and teachers of anatomy but would also be of significant consequence to the teachers of surgery and its allied specialities.

The unique feature of applied aspects in this book is due to the fact that Dr Kadasne is a qualified Anatomist as well as Surgeon of cognition and repute.

I take the privilege of saluting the 'unending zeal and unfathomable commitment of 'teacher of teachers' respected Dr DK Kadasane Sir, inspite of being aware of the fact that any expression howsoever, genuine and bonafide it be, would not be able to match his creative prowess.

**Vedprakash Mishra**
Chairman
Post Graduate Medical Education Committee,
Medical Council of India, New Delhi

# PREFACE

I had the pleasure of teaching Anatomy at the Government Medical College, Nagpur and Surgery at the Indira Gandhi Medical College, Nagpur. I am convinced that surgery brings meaning to anatomy. Surgery is an applied anatomy in the true sense. Anatomy was written and taught by surgeons and physicians in the golden era of rise of medicine. Anatomy was brought to a respectable stage by great surgeons and physicians. It happened in the days when touching of dead and the blood was considered a sin.

The call was given to all the anatomists over the world by a famed and the pioneer surgeon as "Anatomist should come out of the dead house and prove their worth in other clinical sciences. In case of the members of clinical sciences prevent them, the loss is theirs—the loss of humanity".

Every structure in the body has the hidden surgical and clinical thrill of practical importance. It is only on the foundation of anatomy the clinical sciences progressed to the stage of organ transplant. Emergence of the non-invasive techniques of investigation have acted as a boon for anatomy in its further research and clinical application.

Keeping in view the thoughts expressed, I ventured to write a book to create interest and enthusiasm amongst the students while learning anatomy.

*No book is complete and no book can be comprehensive.*

**DK Kadasne**

# ACKNOWLEDGMENTS

My acknowledgements are due to my revered teachers, i.e. Dr NS Sahastrabuddhe, Dr Gopal Rao, Dr SL Robert, Dr PC Bansal and Dr PN Dubey for their support and guidance.

Mr Datta Meghe, MP and the Chancellor of the DMIMS gave me an opportunity to enter into the academic field of teaching anatomy in addition to my surgical practice. This is the major factor which inspired me to write a book of this type.

Mr Sagar Meghe, MLA played a pivotal role in keeping me engaged in the teaching of anatomy. Dr Dilip Gode, presently the Professor of Surgery in Pandit Jawaharlal Nehru Medical College, Sawangi, Wardha has always acted as my well wisher and supporter, whom I can never forget.

I am indebted to Dr Joharapurkar, Director, Datta Meghe Institute, Department of Post Graduate Research and Medical Education and the member of the Management Council for encouragement and support. My thanks are due to Dr Patel, the Dean of the Pandit Jawaharlal Nehru Medical College, Sawangi for appreciation. Dr Mrs Fulzele, Professor and Head of the Department of Anatomy of the Pandit Jawaharlal Nehru Medical College, Sawangi deserves my grateful thanks for discussions during the preparation of the book. Dr Mrs Rawalani deserves thanks for showing interest in my undertaking.

I could not have presented the book in the present form without the generous donation of the clinical material provide by my friends who are renowned experts in their respective fields. Dr Shirish Dhande, a renowned radiologist of the city made the X-rays and the MRI available.

It is my honour that Dr Vedprakash Mishra, Vice-Chancellor of the DMIMS University, Sawangi, Wardha, and the Chairman of Post Graduate Medical Education Committee, Medical Council of India, New Delhi, a doyen in the science of physiology agreed to write a foreword for this book.

Dr GM Taori, the Director of CIMS, Bajaj Nagar, Nagpur whole heartedly co-operated with me in obtaining the consent of the management committee of the institution for permission of using the beautiful cerebral angiogram. The skill and the knowledge of Dr Kothekar, who is the master in his own field need not be highlighted any more.

Dr Prakash Heda of Nairobi, a student and my friend has supported me constantly whether he lived in India or abroad. I thank him sincerely. My thanks also go to Dr Neeta Kulkarni, Professor and Head of the Department of Anatomy, Dr SMCSI Medical College, Karakonam, Trivendrum who always enquired about the progress of the book.

I also thank to Dr Sushma Deshmukh, Dr Ravi Deshmukh, Dr Tule, the pediatric surgeon, and Dr Mukewar, the Director of Gastrointestinal Institute of Central India.

Dr SD Suryawanshi Professor and Head of the Department of Medicine, Indira Gandhi Medical College, Nagpur, acted as my constant critic during the preparation of this book. I thank him profusely.

I have all the appreciation for the work done by Manoj Dharmadhikari for computerised typing of the manuscript. Mr Avinash Kokate did an excellent work in drawing the diagrams artistically with colour. I cannot forget both of them for their devotion and punctuality.

I shall be failing to furnish my duty if I do not express my gratitude to Dr Kishore Taori, the dynamic professor of radiology of the Government Medical College, Nagpur for providing me the necessary material for the production of this book.

My better half, Mrs Arati Kadasne, took pains to go through the manuscript and helped me untiringly till the completion of the book.

Dr Shivraj Mulik, ophthalmic surgeon provided actual photographs of fundoscopic examination showing retinal vessels. Dr BJ Chikodi, Ex-civil Surgeon and Dr JS Mulik, ophthalmic surgeon encouraged me in the production of this book. I express my gratitude to them.

My thanks also go to Dr Dasgupta, Dean, Lata Mangeshkar Medical Hospital, who provided the clinical photographs for publication of my book and Dr Kothe, the plastic surgeon who provided beautiful clinical photographs of cleft lip and palate.

My thanks are due to Dr Padole, surgeon and Dr Neral and Dr Jape, radiologists for their encouraging comments and helping hands. Dr Mrs Pushpa Jagtap, Ex-Dean of Indira Gandhi Medical College, Nagpur and her two brilliant sons, namely Dr Prashant, cardiovascular surgeon of Wockhardt Hospital, Nagpur and Dr Jitendra Jagtap, renowned orthopedic surgeon have extended their supports whole heartedly, I cannot forget them. Dr Mangrulkar took pains to provide necessary photographs for their reproduction, I am also grateful to him. Dr KN Ingle, Professor of Pandit Jawaharlal Nehru College, Sawangi, Wardha has always acted as my source of inspiration, so, I cannot forget him.

I am under the heavy obligations of Hon'ble Datta Meghe, MP and the Chancellor of Datta Meghe Institute of Medical Sciences for the friendly approach, advice and appreciation, who allowed me to continue my academic association with the subject of anatomy by appointing me as Professor Emeritus of Anatomy in his prestigious institute. It is this institute which encouraged me to continue my academic activity. Although I was engaged in my surgical practice, the credit for production of this book goes to the DMIMS. I cannot forget the friendly and helpful approach of the Professor of surgery, Dr Vinay Shahapurkar, who also made available so many clinical photographs in the publication of this book.

I am grateful to Shri Jitendar P Vij, CMD of M/s Jaypee Brothers Medical Publishers Pvt. Ltd. for publishing this book. I acknowledge the contribution of Mr Tarun Duneja, the Director (Publishing) of Jaypee Brothers and his team particularly Mr DC Gupta (Copyeditor), Ms Seema Dogra (Cover Designer) and Mr Sumit Kumar (Graphic Designer) who deserve my sincere thanks. I am extremely grateful to my beloved students who always appreciated and inspired me for teaching the subject. Last but not least, I am extremely grateful to Almighty who has allowed me to achieve my goal.

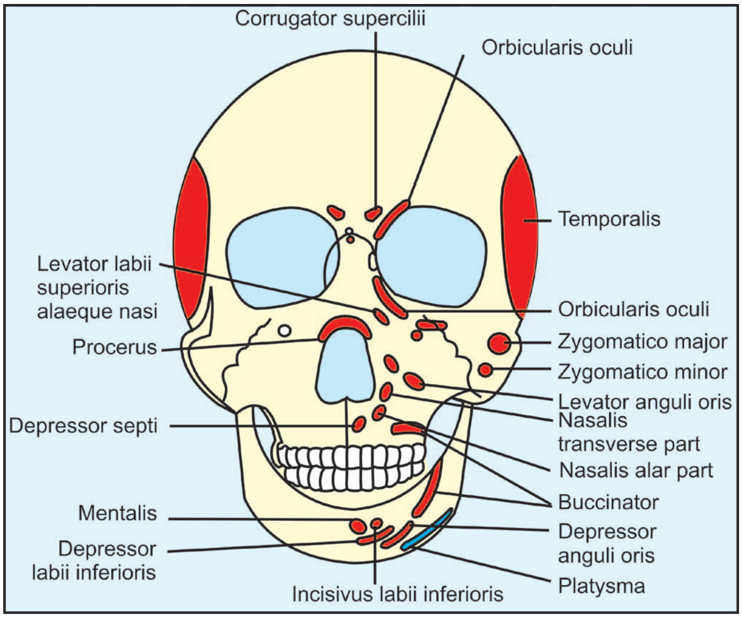
# CONTENTS

# OSTEOLOGY OF HEAD, NECK AND THE FACE

**Norma Frontalis (Figure 1):**

Forehead is formed by the frontal bone. Frontal eminences are placed above the orbital openings. Orbital openings are quadrilateral on either side of the external nasal apurture. Below and between the orbital openings is the anterior nasal aperture. It is piriform in shape and presents an anterior nasal spine lower down where maxillae meet. Nasal opening is bounded by the maxillae and nasal bones. Nasal bones join the frontal bone above and meet the nasal bone of the opposite side. Meeting of the frontal and nasal bones is known as the nasion. Above the nasion is the smooth raised area known as the glabella. Running on either sides of glabella are the superciliary arches. They are situated above the medial part of the superior margin of orbital opening. Above and lateral to the super cilliary arches are the frontal eminences.

**Figure 1**
Showing norma frontalis




Zygomatic arch is formed by the zygomatic process of the temporal bone and the temporal process of the zygomatic bone. Frontozygomatic suture is at the lateral border of the orbit. It can be palpated with a finger. It is an important landmark for surface marking of the middle meningeal artery. Superior margin of the orbital opening presents a notch or a foramen at the junction of its lateral 2/3rd and the medial 1/3rd. It is known as the supraorbital notch or foramen. Supraorbital vessels and the nerves pass through it. Lateral border of the opening of orbit is formed by the zygomatic bone below and the zygomatic process of the frontal bone above. Inferior border of the orbital opening is formed by the maxilla medially and zygomatic bone laterally. Infraorbital opening is placed half a centimeter below the lower margin of the orbit. It gives passage to the infraorbital vessels and the nerves. Medial margin is formed by lacrimal crest of the maxilla and the lacrimal bone. Nasal bones form the upper limit of the nasal aperture. They are notched or may present small foramina at the lower margins, is for the external nasal nerve. Please remember that the tip of nose is supplied by the external nasal nerve and

when pressed it feels firm. Alveolar margin contains sockets for the eight teeth on the each half.

Incisive fossa lies above the incisors. Canine eminence lies over the canine while the canine fossa is lateral and the incisive medial to the canine eminence (Figures 2 and 3).

**Figure 2** Showing detail of canine eminence

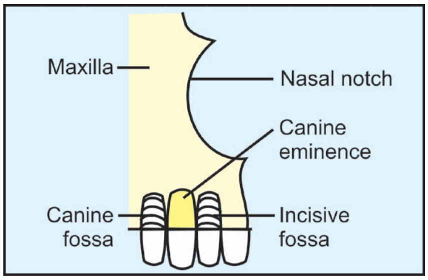
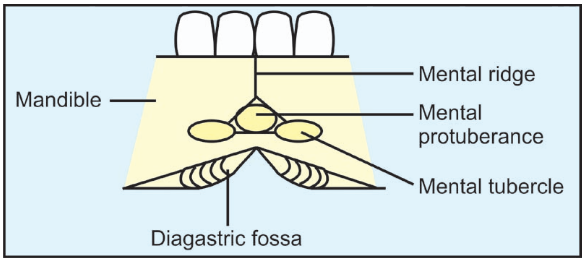



**Figure 3** Showing landmarks in front of the symphysis menti




Muscles of the face arise from the bones and are inserted into the skin. They are not covered by the deep fascia thus making them more expressive for the sake of facial expressions.

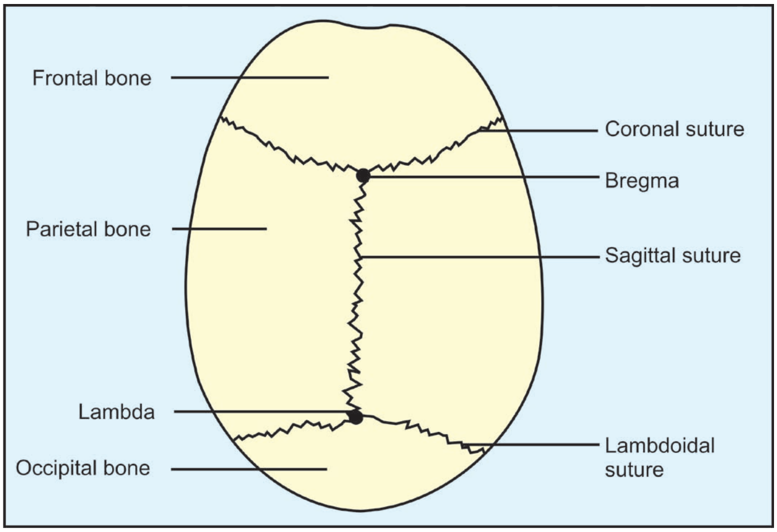
Medial aspects of the supercilliary arch gives origin to the corrugator supercilliary muscle. Nasal process of the frontal bone and the frontal process of the maxilla give origin to the orbital part of orbicularis oculi. Between these two, the medial palpable ligament is attached to the frontal process of the maxilla.

Procerus muscle is attached to the nasal bones in the midline. Lavator labii superioris arises from the maxilla between the inferior margin of orbit and infraorbital foramen. Zygomaticus major and the minor arise from the body of the zygomatic bone, major being lateral.

**Norma Verticalis (Figure 4):** It is ovoid in shape and its maximum width is near the occipital pole. It presents frontal bone anteriorly separated from the two parietal bones by the coronal suture. Parietal bones articulate in the midline through the sagittal suture. Occipital bone articulates with the parietal bones through lambdoidal suture. Meeting point of the coronal and sagittal suture is known as bregma. At birth it is occupied by a diamond shaped fibrous membrane. It is known as anterior fontanellae. It closes at the age of one and half year. Lambda is situated at the meeting point of the sagittal and the lambdoidal sutures. It is occupied by a triangular fibrous membrane known as the posterior fontanellae. Parietal eminences are placed postero-laterally. Emissary parietal foramen is situated by the side of the sagittal suture 3.5 cm in front of the lambda. It gives passage to the emissary vein which drains into the superior sagittal sinus.

**Norma Lateralis (Figures 5 and 6):** It is formed by nine bones, namely the frontal, parietal, occipital, zygomatic, sphenoidal, temporal, nasal, maxilla and the mandible. Out of these frontal, sphenoidal, occipital and the maxilla are single bones placed near the midline. Prominently this view presents zygomatic arch, external acoustic

**Figure 4**
Showing norma verticalis




meatus and the mastoid process. Above the zygomatic arch lies the temporal fossa. It is bounded by the superior and the inferior temporal lines above, the frontal crest anteriorly and the supramastoid crest posteriorly.

**Figure 5**
Showing bones taking part in norma lateralis

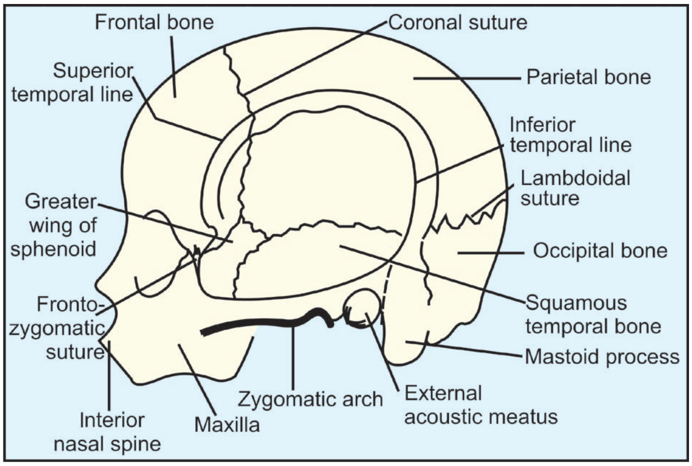
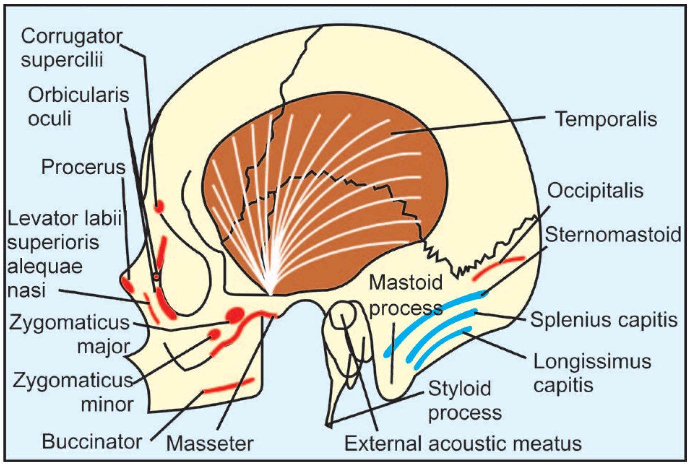



**Figure 6**
Showing norma lateralis



**The Floor of the Superficial Temporal Fossa (Figure 7):**

The floor of the superficial temporal fossa is formed by the four bones namely, the frontal, parietal, greater wing of sphenoid and the squamous part of the temporal. They are united by the H shaped suture located at the anteroinferior angle of the parietal bone. Meeting point of the four bones is marked by circular area. It is known as the pterion. It is an important surface landmark for the surface marking of the anterior division of the middle meningeal artery. It is marked at a point 4 cm above the zygomatic arch and 3.5 cm behind the frontozygomatic suture. It marks the axial position of the stem of lateral sulcus (Sylvian sulcus). It is also called as the Sylvian Point.

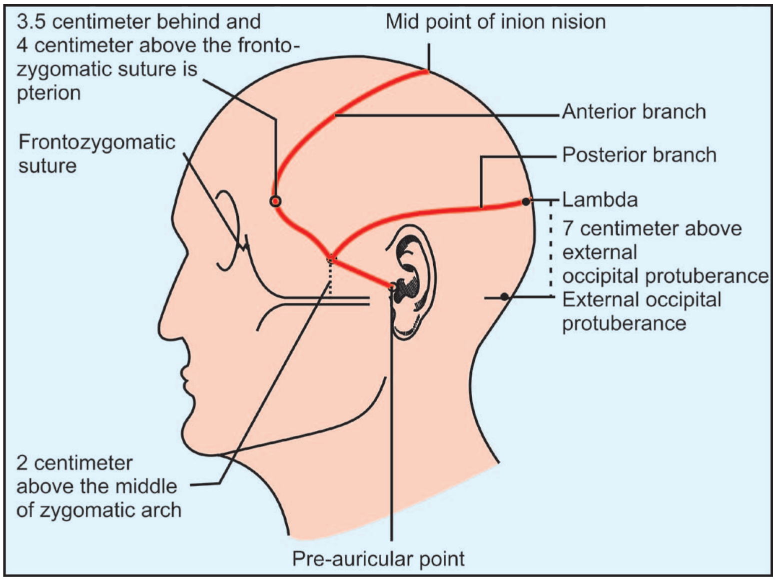



**Figure 7** Showing surface marking of middle meningeal artery

Temporal surface of the zygomatic bone, part of the greater wing of the sphenoid, part of the frontal bone form the anterior limit of the temporal fossa. All these structures separate the temporal fossa from the orbit. Anterior part presents zygomatico-temporal foramen which transmits zygomatic nerve. Temporal fossa communicates with infratemporal fossa through the gap between the zygomatic arch and the lateral wall of the cranium. The tendon of temporalis, deep temporal vessels and nerves pass through it. The tendon of temporalis comes down, while the deep temporal vessels and nerves go up. Zygomatic arch can be palpated between the cheek and the temple. It is formed by the temporal process of the zygomatic bone and the zygomatic process of the temporal. The suture between the two is obliquely placed (zygomatico-temporal suture). Upper border of the zygomatic arch gives attachment for the superficial layer of the temporal fascia. Its medial surface and the lower border give origin to the masseter muscle. Deep layer of the temporal fascia merges with the fascia on the medial aspect of the masseter. Zygomatic process of temporal bone divides into two roots posteriorly near the temporal bone. Anterior root turns medially to form the tubercle of the root of the zygoma and the anterior boundary of the mandibular fossa as an articular eminence. Posterior root runs posteriorly, lateral to the mandibular fossa and joins the supramastoid crest (Figure 8).

Postglenoid tubercle is the part of the posterior root of the zygoma. It lies behind the mandibular fossa (Figure 8).

**External Acoustic Meatus (Figure 8):** External Acoustic Meatus lies posteroinferior to the posterior root of the zygomatic arch. Posterosuperior margin of the meatus is formed by the squamous part of the temporal bone and the anteroinferior margin is formed by the tympanic plate.

Anterosuperiorly is the squamotympanic suture and posteriorly is the tympanomastoid suture, which presents canaliculus for the auricular branch of the vagus. (Nerve of Arnold).

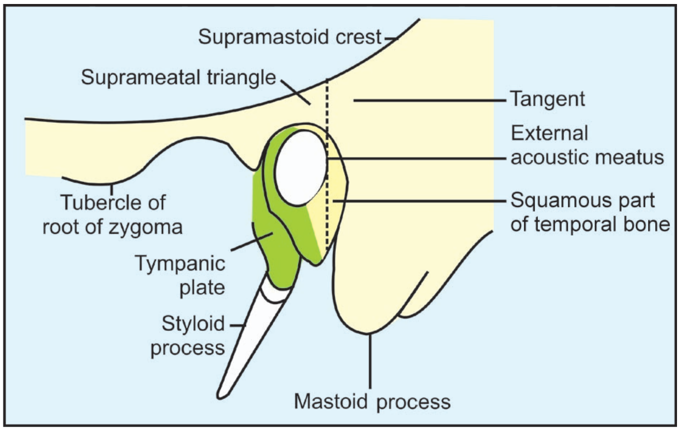



**Figure 8**
Showing external acoustic meatus with supra meatus triangle tympanic plate and styloid process

**Suprameatal Triangle (Figure 8):** It is situated posterosuperior to the external acoustic meatus. It is bounded above by the supramastoid crest, anteriorly the margin of the external acoustic meatus and posteriorly by the tangent drawn from the posterior margin of the meatus. It may present a spine known as suprameatal spine. Suprameatal triangle is known as the MacEwen triangle. It is the surface landmark for the tympanic antrum (Mastoid Antrum).

**Mastoid Process:** It is the bony projection situated behind the external acoustic meatus. It can be palpated under the lobule of the ear. It has two sutures namely, i.e.

1. Parietomastoid
2. Occipitomastoid.

Parietomastoid suture is situated at the posteroinferior parietal angle and the occipitomastoid suture in between the posterior border of the mastoid and the occipital bone. These two sutures meet the lambdoidal suture, at the point known as asterion.

Mastoid foramen is situated near the posterior border of the mastoid process. It transmits emissary vein from the sigmoid sinus and the small dural branch of the occipital artery. Asterion is the site for the postero-lateral fontanelle. Mastoid process develops in the second year of life. At birth absence of mastoid process leaves the facial nerves unprotected. Although the mastoid process develops in the second year of life, the mastoid air cells develop at the age of six years. At times mastoid process has no air cells and is called the acellular mastoid.

**Styloid Process:** Styloid process like a thick pointed needle attached to the base of the skull. It runs downwards forwards and medially. Its tip goes upto the posterior border of the ramus of mandible. Its length varies from few mm to few centimeters (about 2.5 cm). It is attached to the lesser cornu of the hyoid bone by the stylohyoid ligament. Stylomastoid foramen lies posterior to its base. Tympanic plate forms the sheath around the base of the styloid process.

**StyAlgia (Eagles' Syndrome):** Long styloid reaching tonsillar fossa can cause pain in the tonsillar region which increases during swallowing. The pain is referred to the neck and

the ear of the same side. The process can be palpated transorally at the site of the tonsillar fossa with the finger. The long styloid process can be seen in a radiograph. Ossified stylohyoid ligament may be seen in few cases.

**Infratemporal Fossa (Figures 9A and B):** Infratemporal fossa is situated below the level of the zygomatic arch under the skull. It communicates with the temporal fossa through the gap between the zygomatic arch and the infratemporal crest of the greater wing of sphenoid.

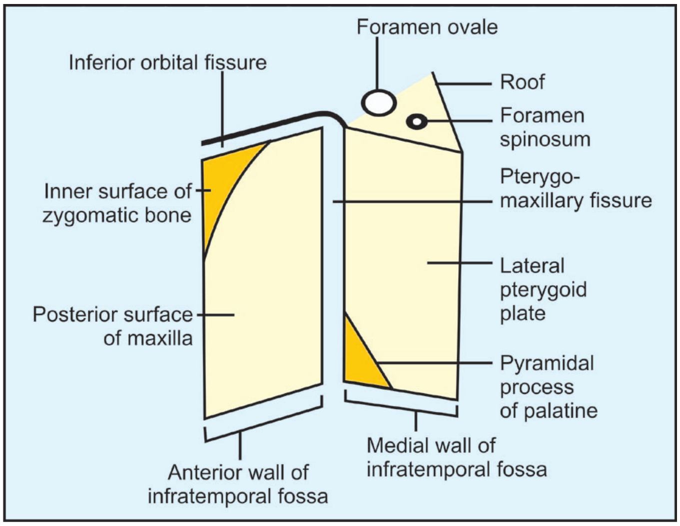



**Figure 9A** Showing anterior and medial walls of the infratemporal fossa. Note: foramen ovale spinosum in the roof

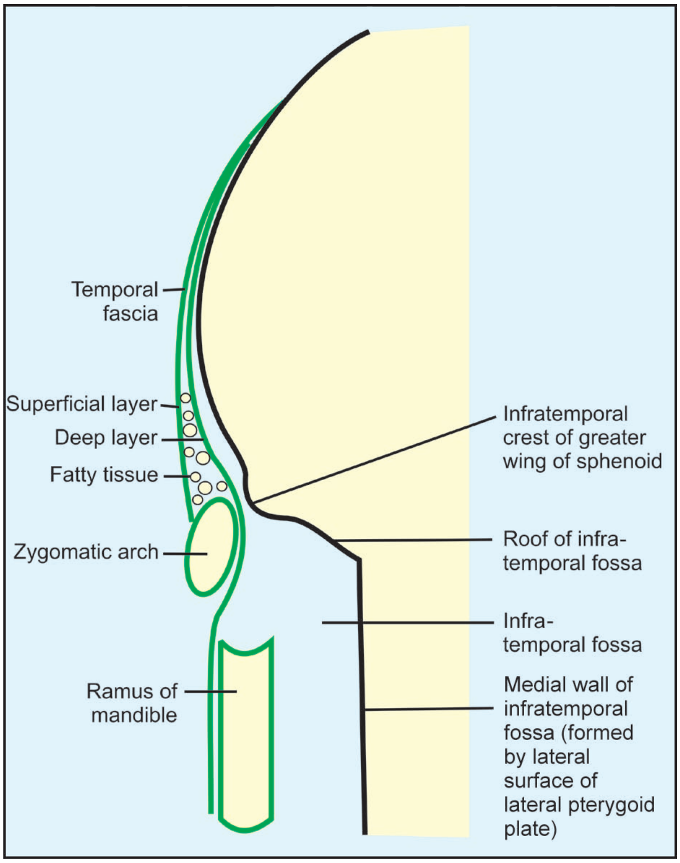



**Figure 9B** Showing temporal fascia and the infra-temporal fossa

**Medial Wall:** It is formed by the lateral pterygoid plate and the pyramidal process of palatine.

**Roof :** Roof is formed by the infratemporal surface of the greater wing of sphenoid and partly by the squamous part of the temporal bone. It presents two foramina: (1) foramen ovale and (2) foramen spinosum.

Foramen ovale transmits the mandibular, lesser superficial petrosal nerves, accessory meningeal artery (MLA). Foramen spinosum gives passage to the middle meningeal artery and the nervous spinosus.

**Anterior Wall:** Anterior wall is formed by the posterior surface of the maxilla and the medial surface of the zygomatic bone.

**Lateral Wall:** Lateral wall is formed by the ramus of the mandible.

*Infratemporal fossa has no floor and is without the posterior wall:*

**Communications:** It communicates with the pterygopalatine fossa through the pterygomaxillary fissure which lies between its medial and the anterior walls of the infratemporal fossa. It also communicates with the orbit through the infraorbital fissure which lies between the roof and the anterior wall of the fossa.

**Pterygomaxillary Fissure:** It lies betwen the lateral pterygoid plate and the maxilla (Figure 9A). Maxillary artery enters the pterygopalatine fossa through the pterygomaxillary fissure.

# PTERYGOPALATINE FOSSA

It is situated at the apex of the orbit. Its walls are formed as under (Figure 10):

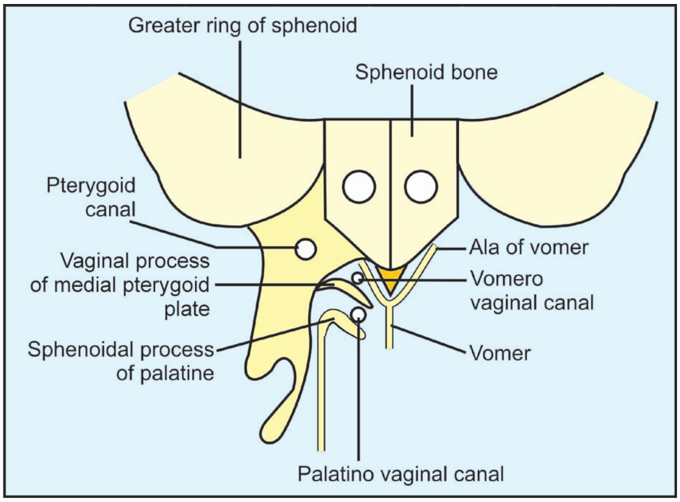



**Figure 10** Showing vomero vaginal and palatino vaginal canal. Please note pterygoid canal in the root of the pterygoid processes

**Posterior Wall:** By the roots of pterygoid processes and part of the greater wing of the sphenoid.

**Medial Wall :** Perpendicular plate of the palatine and its two processes the orbital and the sphenoidal. Orbital and the sphenoidal processes of the palatine enclose the nasopalatine foramen, which transmits the nasopalatine vessels and nerve to the nasal cavity.

**Anterior Wall:** It is formed by the posterior surface of the body of maxilla.

**Lateral Wall:** It presents pterygomaxillary fissures which connects it to the infratemporal fossa.

**Floor :** A foramen is placed between the anterior and the posterior walls inferiorly leading to the greater palatine canal lower down. It runs between the maxilla and the perpendicular plate of the palatine. It transmits anterior, middle and the posterior palatine nerves and the greater and lesser palatine vessels which escape below on the hard palate.

Pterygoid canal is situated inferomedial to the foramen rotundum. It transmits nerve of the pterygoid canal. Nerve of the pterygoid canal is formed in the foramen lacerum by union of the greater superficial petrosal nerve coming from the geniculate ganglion of the facial and the deep petrosal nerve from the sympathetic plexus of the internal carotid artery. Nerve of the pterygoid canal joins the pterygopalatine ganglion in the pterygopalatine fossa. It carries secretomotor for the lacrimal gland.

Vaginal process of the medial pterygoid process intervenes between the ala of the vomer above and the sphenoid process of the palatine below. Thus forming the vomero-vaginal canal above and palatinovaginal canal below. Palatinovaginal canal is placed inferomedially and it transmits the pharyngeal nerve and the artery (Figure 10).

Middle temporal vessels produce vascular markings above the external acoustic meatus. Zygomatico-temporal foramen in the anterior wall of the temporal fossa transmits zygomatico-temporal nerve and the small artery. Tubercle of the root of zygomatic bone gives attachment to the temporo-mandibular ligament.

Postero-lateral surface of the mastoid process near the base gives insertions to sternomastoid, splenius capitis and the longissimus capitis muscles antero-posteriorly. Mastoid canaliculus at the base of the mastoid and transmits auricular branch of vagus.

**Styloid Process :** It lies medial to the parotid gland. Attachments of the styloid process from above downward are

1. Stylopharyngeus
2. Stylohoid and
3. The genioglossus muscles.

Stylopharyngeus is attached at the base, stylohoid in the middle and the styloglossus at the tip along with stylohoid ligament.

Facial nerve comes out of the stylomastoid foramen and crosses the styloid process.

**Contents of Infratemporal Fossa:** Infratemporal fossa contains the lateral and the medial pterygoid muscles, maxillary artery, mandibular nerve, middle meningeal artery, nervous spinosus, spine of sphenoid. Medial to the base of the spine of the sphenoid is the chorda tympani nerve and lateral to it is the auriculotemporal nerve. Tip of the spine of the sphenoid gives attachment to the spinomandibular ligament.

In addition to the above it contains pterygoid venous plexus, and the otic ganglion. Superficial head of the medial pterygoid muscle arises from tuberosity of maxilla and the pyramidal process of the palatine bone. The alveolar margin of the maxilla gives origin to the buccinator muscle.

**Norma Basalis (Figure 11):** Anteriorly, it present hard palate formed by the palatine processes of the maxillae and the horizontal plates of the palatine bones. Anterolaterally is the curved margin of the superior alveolar arch having teeth. Anteriorly in the midline it presents the incisive fossa and the posterior nasal spine posteriorly. A little in front of the posterior border of the hard palate are the palatine crests. Lateral end of the palatine crests presents the greater and the lesser palatine foramina. Rest of the surface of the hard palate presents numerous pits for the palatine glands.

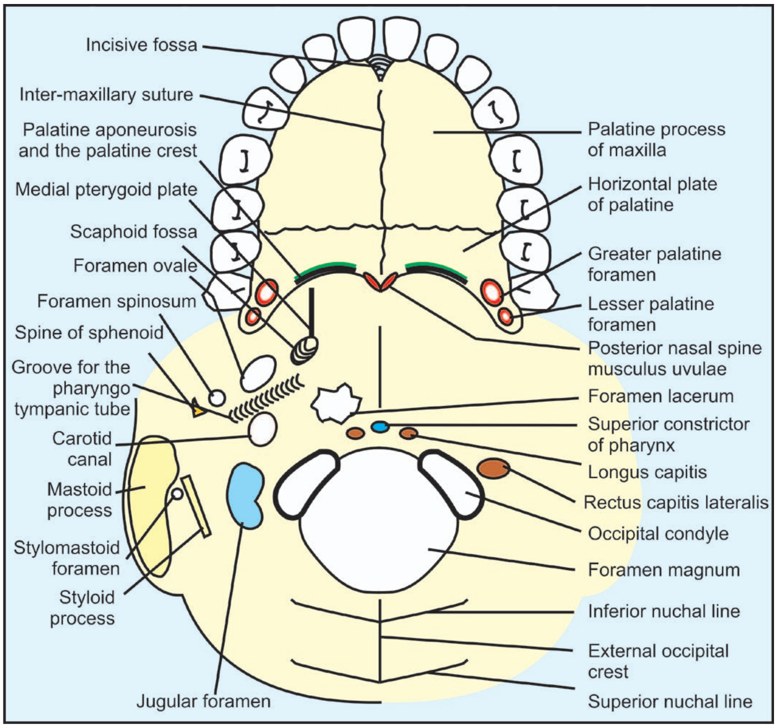



**Figure 11**
Showing norma basalis

Lesser palatine foraminas are posterior to greater and are situated on the pyramidal process of the palatine bone. The pyramidal process of the palatine bone lies between the medial and the lateral pterygoid plates. Greater palate foramina gives passage to the greater palatine vessels and the nerve. Greater palatine vessel goes forwards running in the groove towards the incisive fossa. Lesser palatine foramina transmits lesser palatine vessel and the nerve. Palatine crest gives attachment to the tendon tensor villi palatini muscle. Posterior border of the hard palate gives attachment to the palatine aponeurosis of the tensor palati muscle. Musculus uvulae is attached to the posterior nasal spine. Inter maxillary suture may present the raised palatine torus.

**Middle Part of Norma Basalis:** Posterior border of the vomer divides the nasal aperture into two. Posteriorly body of the sphenoid joins the basilar part of the occipital bone, which ends anteriorly at the foramen magnum. This part is wider posteriorly and presents a small tubercle known as pharyngeal tubercle. It gives attachment to the highest fibers of the superior constrictor muscle. The pterygoid processes descend down from the junction of the body of sphenoid and the greater wing. The pterygoid process presents medial and lateral pterygoid plates enclosing the pterygoid fossa. The medial pterygoid plate articulates with the perpendicular plate of the palatine and helps in forming the lateral wall of the nasopharynx and the nasal aperture. They are separated from the maxilla by the pterygomaxillary fissure. Posterior border of the medial pterygoid plate has tubercle at the midpoint which gives attachment to the pharyngotympanic tube. Near the base of the skull medial pterygoid plate presents the scaphoid fossa. Lower down its projection is in the form of hook like process known as pterygoid hamulus. The tendon of the tensor villi palatini grooves it anteriorly and hooks, to reach the soft palate. Running down from the tip of the pterygoid hamulus to the mandible behind the last molar is the pterygomandibular ligament. It gives origin to the lower part of the superior constrictor muscle posteriorly and the buccinator anteriorly. Lateral pterygoid plate forms the medial wall of infratemporal fossa. Infratemporal surface of the greater wing of sphenoid presents foramen oval, foramen spinosum and the spine of sphenoid in the posterolateral order in the roof. Groove for the pharyngotympanic tube lies between the infratemporal surface of the greater wing of the sphenoid anterolaterally and the petrous temporal bone posteromedially. Petrous part of the temporal bone presents an opening of the carotid canal which lies posterior to the foramen oval and posterolateral to the foramen lacerum.

Medial pointing part of the petrous part of the temporal bone is irregular and is separated by a gap, from the body of the sphenoid and the basiocciput. The gap is known as foramen lacerum. It is closed by the fibrocartilaginus plate and no major structure passes through it except the emissary vein to the carvernus sinus and the meningeal branch of the ascending pharyngeal artery. The internal carotid artery enters the carotid canal and goes anteromedially and appears at the posterior wall of the foramen lacerum. It turns upwards and enters the cranial cavity to enter the cavernus sinus (Cavernus sinuses are the box like paired intracranial venous sinuses situated by the side of body of sphenoid in the middle cranial fossa). Foramen lacerum contains internal carotid artery, deep petrosal nerve, greater superficial petrosal nerve and the nerve of the pterygoid canal.

Squamotympanic suture begins at the base of the spine of the sphenoid and runs posterolaterally between the mandibular fossa anteriorly and tympanic plate posteriorly. Laterally it reaches the anterior border of the

external acoustic meatus. Tympanic plate is triangular, its apex being at the root of the spine of the sphenoid. Its free lateral border forms the anterior border of the external acoustic meatus. Medially, the plate runs lateral to the carotid canal and forms a sheath for the styloid process.

Rostrum of the sphenoid fits into the alae of the vomer and forms the part of nasal septum.

**Palatinovaginal Canal (Figure 10):** Palatinovaginal lies between the vaginal process of the medial pterygoid plate above and the sphenoid process of the palatine bone below. It transmits pharyngeal branch of sphenoplatine ganglion and the pharyngeal branch from the third part of the maxillary artery.

**Vomerovaginal Canal:** It lies between the ala of the vomer above and the vaginal process of medial pterygoid plate below. It opens anteriorly in the palatinovaginal canal.

Medial pterygoid plate has scaphoid fossa at the posterior border near the root. It gives origin to the tensor villi palatini which also arises from the medial margin of the foramen ovale, the base of the spine of the sphenoid and the pharyngotympanic tube. Its fine tendon hooks the pterygoid hamulus to go to the palate.

Posterior border of the medial pterygoid plate is notched above for the attachment of the pharyngotympanic tube and the pharyngobasilar fascia. Lower part of the medial pterygoid plate gives origin to the highest fibers of superior constrictor muscle. Fibers of the superior constrictor muscle ascend upwards to get attached to the pharyngeal tubercle. Lateral surface of the lateral pterygoid plate gives origin to the lower head of the lateral pterygoid muscle while the medial surface gives origin to the deep head of medial pterygoid muscle. Tuberosity of the maxilla and the pyramidal process of the palatine give origin to the superficial head of the medial pterygoid muscle. Head of the mandible articulates with the mandibular fossa, and it is covered with fibrocartilage. Mandibular fossa lies below the middle cranial fossa. It is bounded in front by the articular eminence, which ends laterally in the form of the tubercle of the root of zygoma. Tubercle of the root of the zygoma gives attachment to the temporomandibular ligament. Between the foramen ovale and the foramen spinosum is a small opening known as emissary sphenoidal foramen. It gives passage of an emissary vein from the cavernous sinus.

Spine of the sphenoid gives attachment to the sphenomandibular ligament which is attached to the lingula of the mandible below. Apex of the petrous part of the temporal bone provides origin to the lavator palati muscle.

**Jugular Foramen (Figures 11A and B):** It lies between the occipital and petrous part of the temporal bones antero-lateral to the occipital condyle. In fact it is situated posterior to the opening of the carotid canal. It has a fossa for the superior bulb of the internal jugular vein. Anterior to the jugular foramen lies the tympanic canaliculus. It is meant for tympanic branch of the glossopharyngeal nerve which enters the tympanic cavity (Nerve of Jacobson). Lateral to the jugular foramen is the mastoid canaliculus meant for the auricular branch of vagus (Nerve of Arnold). Medially it presents the notch for the inferior glossopharyngeal ganglion. Apex of the notch receives the opening of the cochlear canaliculus. Jugular foramen gives passage to the inferior petrosal sinus, 9th, 10th and the 11th cranial nerves and the internal jugular vein. (Better say "Vein in front, vein behind and the three nerves in between"). Meningeal branch of the ascending pharyngeal artery accompanies the inferior petrosal sinus and the meningeal branch of the occipital artery accompanies the internal jugular vein.

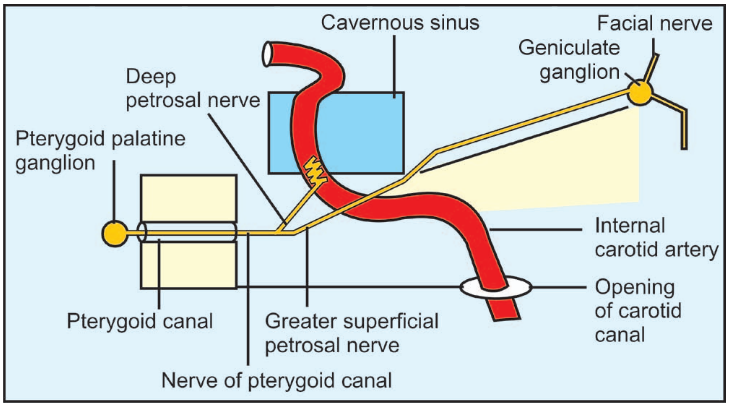



**Figure 11A** Showing intracranial course of internal carotid artery and formation of nerve pterygoid canal

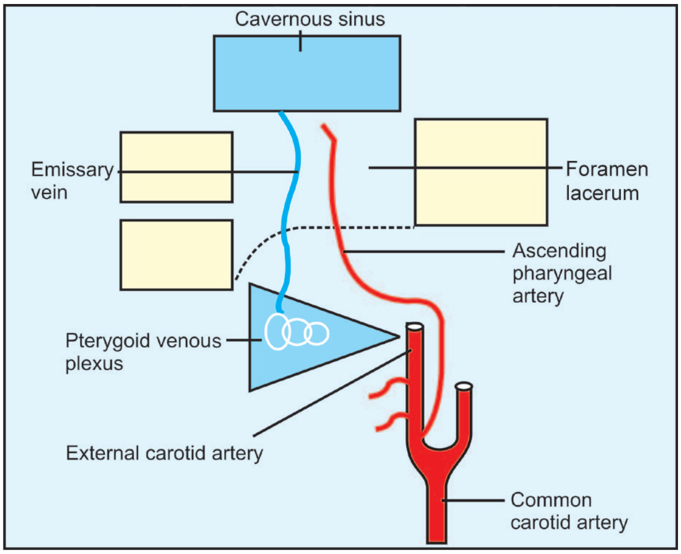



**Figure 11B** Showing structures passing through foramen lacerum. Please remember that no important structure passes through the foramen except mentioned here

**Foramen Magnum:** Foramen magnum is the largest opening situated at the base of the skull. It connects the cranial cavity with the vertebral canal. Medulla oblongata passes through the opening and continues as the spinal cord. Its diameter is reduced anteriorly due to the occipital condyles. Hypoglossal canal is anteromedial to the occipital condyle.

**Structures Passing through the Foramen Magnum:** In the anterior compartment are the apical ligament, vertical part of the cruciate ligament and the membrena tectoria. Posterior part of the foramen magnum is broad and it transmits medulla oblongata, meninges with cerebrospinal fluid and the first pair of ligamentum denticulatum. Subarachnoid space contains the spinal root of the accessory nerve, the anterior spinal artery, two posterior spinal arteries, and the two vertebral arteries. Anterior margin of the foramen magnum gives attachment to the anterior atlanto occipital membrane and its posterior margin to the posterior atlanto-occipital membrane. Medial to the mastoid process is the digastric notch which gives origin to the posterior belly of the digastric muscle. Occipital artery produces the bold groove medial to the digastric notch. Hypoglossal canal transmits the hypoglossal nerve, emissary vein from the basilar plexus, and the meningeal branch of the ascending pharyngeal artery.

Jugular process gives attachment to the rectus capatis lateralis. External occipital crest gives attachment to the ligamentum nuchae. Medial part of the superior nuchal line gives origin to trapezius muscle while the lateral part provides insertions to the sternomastoid, splenius capitis and the longissimus capitis muscles. External occipital protuberance is situated in the middle of the superior nuchal line and the external occipital crest runs from it towards the posterior margin of the foramen magnum. Area between

the superior and inferior nuchal lines gives insertion to the semispinalis capatis medially and the obliquus superior laterally. Area below the inferior nuchal lines provides insertions to rectus capitis posterior major laterally and rectus capitis posterior minor medially. Occipital belly of occipito frontalis arises from highest nuchal line. The tubercle in front of the foramen magnum gives attachment to the superior constrictor muscle (pharyngeal tuber). Lateral to the tubercle on either side is the attachment of longus capitis muscle. Rectus capitis laterallis arises from jugular process lateral to the occipital condyles while the rectus capitis anterior arises from the basilar part of the occipital bone anterior to the occipital condyle (Figure 13).

**Norma Occipitalis (Figures 12 and 13):** Norma occipitalis presents the lambdoid suture between the parietal bones and occipital. Meeting point of the lambdoid suture and sagittal suture is known as lambda. The most prominent point is the external occipital protuberance. Running laterally from the external occipital protuberance are the superior nuchal lines. Running from the external occipital protuberance to the foramen magnum is the external occipital crest. The inferior nuchal lines are seen running laterally from the middle of the external occipital crest. The highest nuchal lines are 1 cm above the superior nuchal lines. They are not constant in their appearance hence difficult to spot (Figure 12).

**Figure 12** Showing norma occipitalis

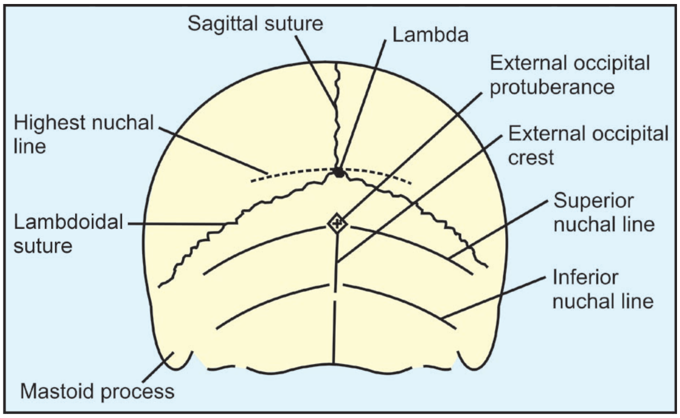
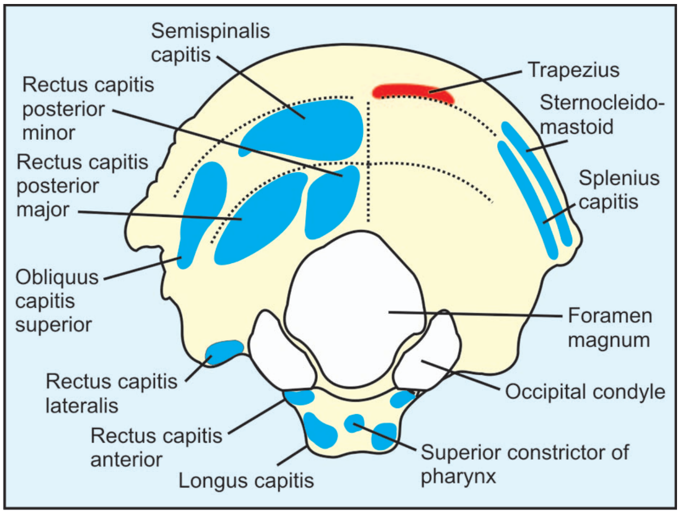



**Figure 13** Showing occipital bone-external surface




*Note:*

**Reid's line:** It extends from the inferior orbital margin to the centre of the external acoustic meatus.

**Frankfurt's line:** It extends from the inferior orbital margin to the upper border of the external acoustic meatus.

# CERVICAL VERTEBRAE

**Atlas:**

Now let us consider the 1st cervical vertebra. It is also known as atlas or ring vertebra. It presents two bulky lateral masses. These are connected anteriorly and posteriorly by means of a short anterior arch and long posterior arch. Lateral mass has an oval or kidney shaped articular area on the superior surface for articulation with the occipital condyles of the skull. Inferior surface of the lateral mass has the circular articular area which articulates with similar area on the body of 2nd cervical vertebra. There are three peculiarities of the atlas which must be remembered (Figure 14).

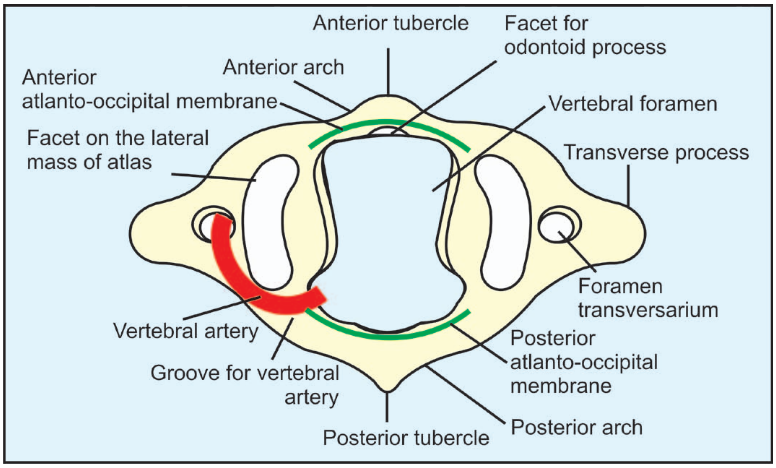



**Figure 14** Showing atlas (superior view)

1. It has no body.
2. Has no spine (Spine is in form of posterior tubercle of atlas). And
3. Has the long transverse process presenting foramen transversarium for the vertebral artery.

Behind the lateral mass on the posterior arch lies the groove for the vertebral artery. Anterior arch presents tubercle anteriorly and facet posteriorly for odontoid process of 2nd cervical vertebra.

**Axis:**

It presents the body, small transverse processes and foramina transversaria. From the superior surface of the body the short and stout process projects upwards which is known as the odontoid process. Anterior surface of odontoid process presents the facet for the anterior arch of the atlas. Situated on the body on either side of odontoid process are circular facets for lateral masses of atlas. Spine of the axis is thick and strong and acts as the lever for the rotation. (Figure 15).

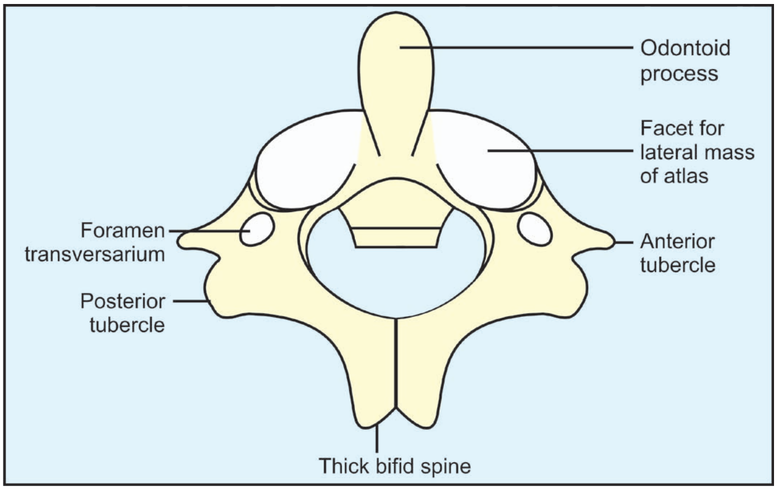



**Figure 15** Showing axis, the second cervical vertebra (viewed from above)

**Seventh Cervical Vertebra (Figure 17):** It is also known as vetebra prominence. It has a long spine the tip of which can be felt if the finger is moved down along the nuchal furrow. It is an important landmark. Foramen transverserium of the seventh cervical vertebra does not give passage to the vertebral artery.

**Clinical:** Abnormal collection of fat over the spine of the seventh cervical vetebra is known as buffalo hump.

**Typical Cervical Vertebra (Figure 16):** Typical cervical vertebra presents a body which is compressed antero-posteriorly. Transverse process presents foramen transversarium. In front and behind foramen transversarium, there are bony roots ending laterally into anterior and posterior tubercles respectively. Laterally foramen transversarium is limited by bar of bone known as costotransverse bar. Spine is bifid. Behind the transverse process lies the articular pillar having superior and inferior articular facets. Intervertebral notch is situated postero-lateral to the body. This intervertebral notch is converted into intervertebral foramen with the help of vertebra above. It must be noted and remembered for ever that the intervertebral foramen in the cervical region cannot be seen from the lateral side. It is only because of this fact, when an X-ray of the cervical spine is ordered in a case of cervical spondylitis anteroposterior and oblique views are ordered instead of anteroposterior and lateral.

*Note:* Asking for the lateral view in cases of cervical spondylitis is criminal, as it amounts to total waste of patient's money.

**Figure 16**
Showing typical cervical vertebra

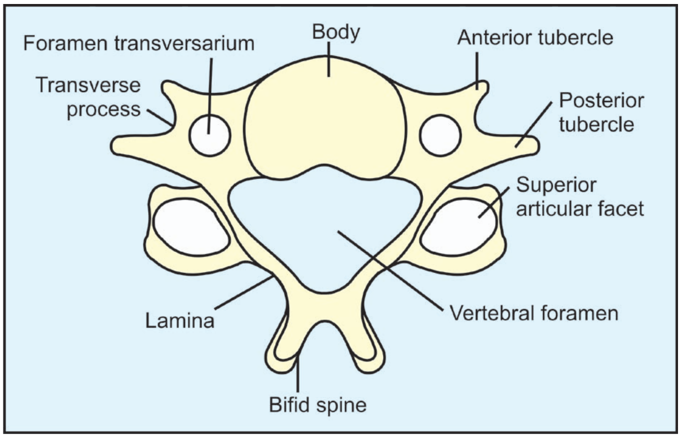
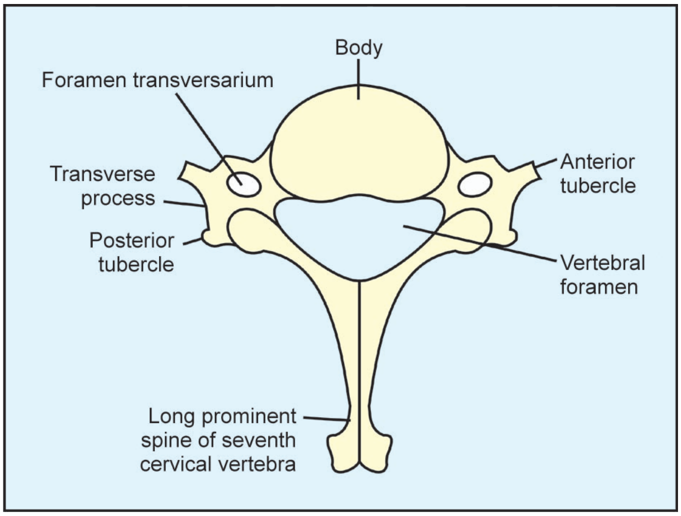



**Figure 17**
Showing seventh cervical vertebra




**Clinical:** There are 3 joints in between bodies of two cervical vertebrae. Central one is formed by means of an intervertebral disc. This is the secondary

cartilaginous joint. On either side of this joint are small synovial joints between two vertebral bodies. These are known as joints of Luschka. It is the osteoarthritis of these joints which leads to formation of bonyspikes (osteophytes). These bony spikes encroach the intervertebral foramina and compress the cervical nerves causing pain on cervical nerves and cause pain in cervical spondylitis.

# MANDIBLE

Mandible is developed from the first pharyngeal arch. It has the body and two rami. Body is horse shoe shaped and the rami projects upwards from the body. The meeting point of the posterior border of the ramus with the lower margin of the body is known as the angle of mandible, where the stylomandibular ligament is attached (Figures 18 and 19).

**Figure 18**
Showing mandible external surface

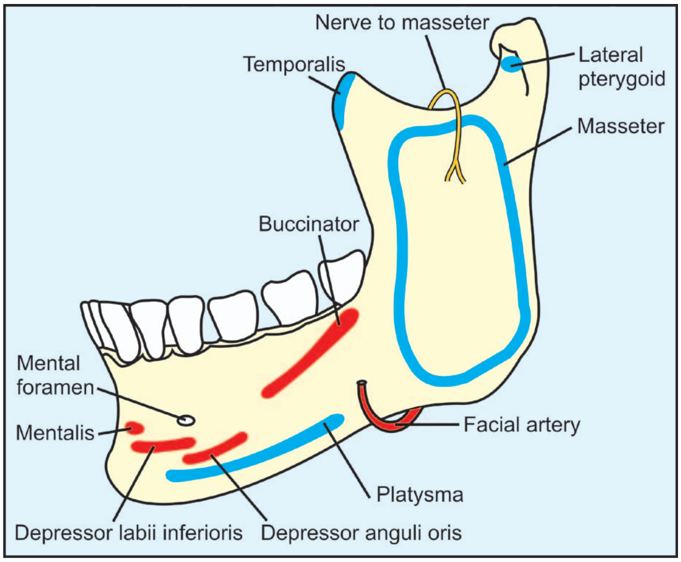
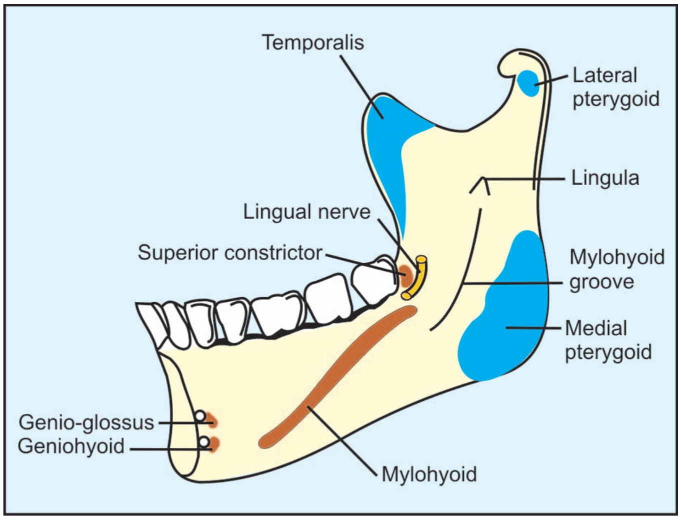



**Figure 19**
Showing mandible internal surface




**Body of the Mandible:** It presents superior and inferior borders, outer and inner surfaces. Union of the two halves of the body is marked by the ridge known as symphysis menti. The median raised area is known as the mental protuberance, the mental tubercles are situated below and lateral to the mental protuberance (Figure 3).

**Oblique Line:** Oblique line is the lower and forward continuation of the anterior border of the ramus.

It runs towards the mental tubercle. It gives origin to the buccinator muscle. The inferior border of the body of the mandible presents the digastric fossa in the midline.

Inner aspect of the body of the mandible has the oblique line which gives origin to the mylohyoid muscle. The line divides the sublingual fossa from the submandibular. Posterior to the symphysis menti are the superior and inferior genial tubercles which give origin to the genioglossus and the geniohyoid muscles respectively. Diagastric fossa gives origin to the anterior belly of the digastric. Mylohyoid groove is seen below the mylohyoid line which is meant for the mylohyoid nerves and the vessels.

**Ramus of the Mandible:** It is quadrilateral and has the anterior, posterior, superior inferior borders and the inner and the outer surfaces. The oblique line runs downwards from the anterior border of the ramus of the mandible. It gives origin to the buccinator muscle. The mandibular foramen, lingula of the mandible and the mylohyoid groove are seen on the medial surface of the ramus. Lingula is the tongue like process projecting from the anterior border of the mandibular foramen. It is directed upwards. Mandibular foramen is meant for the inferior dental nerve and the vessels which run further in the mandibular canal. They supply the lower teeth of each half. Sphenomandibular ligament runs from spine of the sphenoid to the lingula of the mandible below. It is pierced by the mylohyoid nerve and the vessels. Superior border of the ramus of the mandible presents the notch bounded infront by the coronoid and behind by the condyloid processes. The notch gives the passage to the nerve to masseter. Condyloid process has the head. It is expanded transversely and is covered with the fibrocartilage. The head of the mandible articulates with the mandibular fossa of the temporal bone to form the tempero-mandibular joint. Coronoid process provides insertion to the temporalis muscle along its medial surface and the anterior border. Lateral pterygoid muscle is inserted into the front of the neck of the mandible. The site is marked by the pterygoid fovea. Medial to the neck of the mandible are two important structures i.e. the auriculotemporal nerve and the maxillary artery. Posterosuperior part of the lateral surface of the ramus of the mandible is related to the parotid gland. Lingual nerve has an intimate relation with the medial surface of the ramus. Medial surface of the ramus of the mandible between the angle and the lingula gives origin to the medial pterygoid muscle.

Lower border of the body of the mandible provides insertion to the platysma. Behind the last molar the mylohyoid line gives origin to the superior constrictor muscle of the pharynx.

**Clinical:** Fracture of the mandible commonly occurs at the site of the canine. In case of bilateral fracture at the midline, the tongue falls back and the patient gets suffocated and dies if not detected and treated at the earliest. Postoperatively tongue can fall back hence, the anaesthetic puts the airway in the mouth hooking the tongue forwards.

In fracture of the ramus of the mandible the fractured segments do not get displaced as they are well splinted by the muscles i.e. masseter laterally and the medial pterygoid medially.

Fracture of mandible involving the tooth bearing margin are compound as the fracture line is exposed to the outside.

It is due to anatomical fact that the mucoperiosteum is firmly attached to the alveolar margin. There is swelling, bruising at the site of mandibular fracture accompanied by the haematoma in the floor of mouth. It is known as Coleman's sign.

# MAXILLA

Maxillae contributes to the formation of the face. Together they form the skeleton of the face, part of the nose, part of the orbit and anterior wall of the infratemporal and the pterygopalatine fossae. If the face is divided into three equal parts upper, middle and the lower. Frontal bone occupies the upper mandible, the lower and the maxillae the middle. Maxilla presents the body and four processes namely the frontal zygomatic alveolar and the palatine. Body of the maxilla is pyramidal in shape having its base directed medially towards the lateral wall of the nose. The apex is directed towards the zygoma. It has the base, apex, superior, inferior, posterior and anterior surfaces. Superior surface forms the orbital floor and the inferior forms the roof of the oral cavity. Anterior surface points towards the face and the posterior surface forms the anterior wall of the infra-temporal fossa (Figures 20 and 21).

**Figure 20** Showing maxilla side view

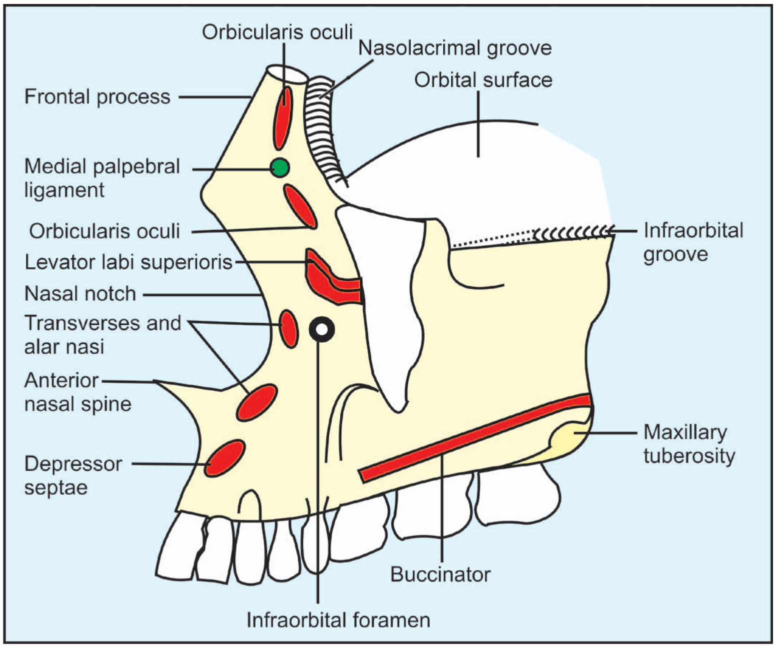
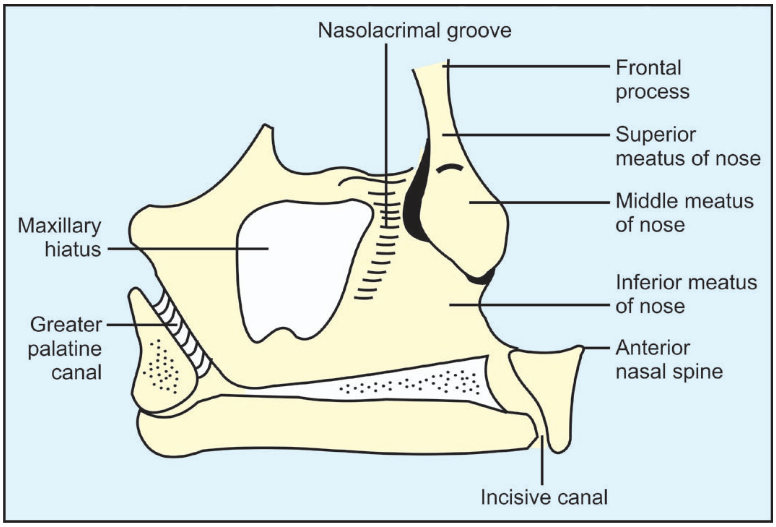



**Figure 21** Showing medial aspect of maxilla



Maxilla articulates with the

1. Frontal bone above
2. Zygomatic laterally
3. Palatine posteriorly
4. With the maxilla of the opposite side.
5. Lacrimal bone
6. Inferior concha
7. Ethmoid

The maxillary hiatus which opens into the middle meatus of the nose is bounded above by the lacrimal and ethmoid. Posteriorly by the perpendicular plate of the palatine and below by the inferior concha.

Zygomatic process of the maxilla forms the anterior wall of the infratemporal fossa. Medial margin of the anterior surface of the maxilla forms the nasal notch which forms the boundary of the anterior nasal aperture. Superior surface of the body of the maxilla has the groove meant for the infraorbital nerve which enters the infraorbital canal and opens anteriorly 4 mm below the infraorbital margin on the face.

Anteromedial part of the orbital surface has a small notch which forms the limit of the canal for the nasolacrimal duct.

Orbital surface of the maxilla articulates with the zygomatic, ethmoidal and lacrimal above. Posterior surface of the maxilla forms the inferior limit of the infraorbital fissure. The zygomatic process is strong and thick and it forms the partition between the infratemporal fossa and the orbit. Palatine processes forms the hard palate. It articulates posteriorly with the horizontal plate of the palatine. Nasal crest of the maxillae fits into the vomer and helps in forming the nasal septum. Frontal process of the maxilla projects posterosuperiorly and articulates with the frontal bone above, nasal bone infront and the lacrimal behind. External surface of the frontal process has the lacrimal crest which continues as the inferior margin of the orbit. The lacrimal crest gives attachment to the medial palpebral ligament.

**Maxillary Air Sinus (Figure 22):** Maxillary air sinus is the largest of the paranasal air sinuses situated in the body of the maxilla. It is also known as the antrum of Highmore. It is pyramidal in shape having the base directed medially towards the lateral walls of the nose where it opens into the hiatus semilunaris of the middle meatus of the nose below the bulla ethmoidalis. The opening of the maxillary air sinus is placed at the higher level than the floor of maxillary air sinus.

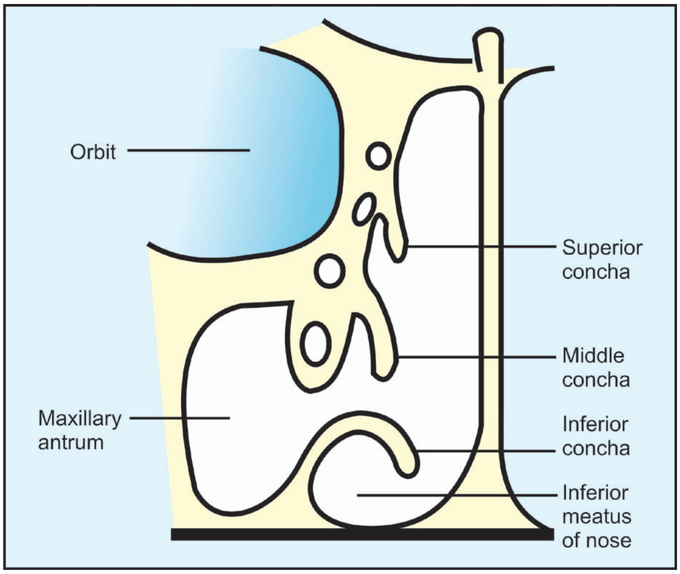



**Figure 22** Showing cross section of maxillary antrum nasal cavity including orbit

At birth the floor of the maxillary sinus and the floor of the nasal cavity are at the same level. Maxillary air sinus at times has an accessory opening. Frontal air sinus drains into the middle meatus of the nose through the infundibulum into the hiatus semilunaris. Therefore, the secretion of the frontal air sinus finds it easy to enter the maxillary air sinus.

*No wonder that maxillary air sinus is known as the secondary reservoir of the frontal air sinus.*

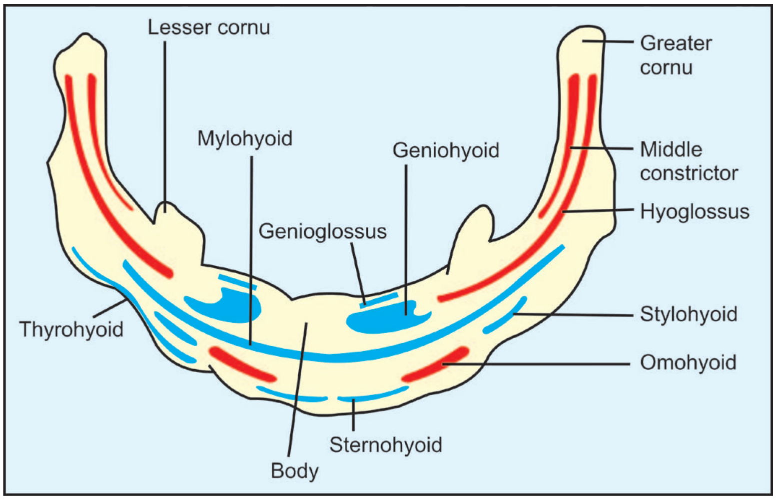
Maxillary air sinus is lined by the ciliated columnar epitheilum. It has a capacity of 25 to 50 cc. It is the first paranasal air sinus to develop in the fourth month of intra-uterine life as the diverticulum of the nasal cavity and marks its proxy at birth being the only air sinus present at birth.

**Clinical:** Carcinoma of the maxilla spreads to the orbit above, oral cavity below, nasal cavity medially and the infratermporal fossa posteriorly. This causes involvement of the important structures such as mandibular nerve. Extension of maxillary carcinoma medially leads to nasal bleeding and obstruction. Its spread towards the orbit causes proptosis of the eye. Its oral extension can be seen as a cauliflower like growth, peeping through the eroded and perforated hard palate.

**Caldwell Luc's Operation:** Maxillary sinus is opened anteriorly through the upper gum at the incisive fossa. After removal of diseased mucosa, operation ends by creating the window in the inferior meatus of the nose. Maxillary antrum can be approached endoscopically.

**Hyoid Bone (Figure 23):** Hyoid bone develops from the second pharyngeal arch. It has the body, two greater and two lesser cornu. Attached to the lesser cornu is the stylohyoid ligament and to the greater cornu is the lateral thyrohyoid ligament. Running from the inferior border of the body of the hyoid in the midline to the thyroid notch is the median thyrohyoid ligament. Between the upper border of the hyoid bone and the upper border of the thyroid lies the thyrohyoid membrane. Thyrohyoid membrane is peireced by the internal laryngeal nerve and the superior laryngeal artery. Internal laryngeal nerve is a branch of the superior laryngeal nerve. Superior laryngeal artery is a branch of the superior thyroid artery, the branch of the external carotid. Thyrohyoid membrane passes posterior to the body of the hyoid and gets attached to its upper border. There is a bursa between the membrane and the body of the hyoid. Thyroglossal duct passes infront below and behind body of the hyoid to go down in the neck. Therefore, during the operation for removal of the thyroglossal fistula the body of the hyoid has to be cut (Sistrunk's Operation).

**Figure 23**
Showing hyoid muscle attachments



# CRANIAL CAVITY

Cranial cavity is irregular due to impressions produced by the cerebral convolutions (gyri), number of foramina and the fissures. Dura mater is firmly fixed to the bone of the cranial cavity. It is continuous with the pericranium outside through the sutures, foramina and fissures. Cranial cavity is divided into three fossae, anterior, middle and the posterior. Lesser wings of the sphenoid and the super borders of the petrous part of the temporal bone form the dividing land marks. Three fossae are not in one plane and are arranged in a step/ladder pattern. Anterior cranial fossa is at the higher plane than the middle cranial fossa; and the middle cranial fossa is still higher than the posterior cranial fossa.

**Anterior Cranial Fossa (Figure 24):** Lateral wall of the anterior cranial fossa is formed by frontal bone. Its floor is formed by the cribriform plate of ethmoid, in the midline, orbital plates of the frontal bone laterally, lesser wings of the sphenoid and part of the body of the sphenoid posteriorly. Cribriform plate forms the roof of the nasal cavity. It presents number of minute foramina, which give passage to the olfactory nerves from the nasal cavity. Anteriorly, in the midline, is the frontal crest of the frontal bone followed by the foramen caecum and the cresta galli. Posterior margin of the cribriform plate articulates with the sphenoid.

Frontal crest intervens between the cerebral hemispheres. Frontal crest and the cresta galli give attachment to the falx-cerebri. Posterior to it is the jugum sphenoidale which separates the fossa from the sphenoidal air sinus in the body of the sphenoid. Jugum sphenoidale forms the anterior limit of the sulcus for the optic chiasma which is connected to the optic canals laterally. Medial end of the posterior border of the lesser wing of the sphenoid forms the anterior clenoid process. It gives attachment to free margin of the tentorium cerebelli. At the lateral margin of the cribriform plate are the minute canals known as anterior and posterior ethmoidal canals. Anterior ethmoidal nerve passes through the anterior ethmoidal canal and escapes through the slit between the cribriform plate and the crista galli to enter the nasal cavity. It continues as external nasal nerve. Posterior border of the lesser wing of the sphenoid fits into the stem of the lateral sulcus.

Gyrus rectus and the olfactory bulb are situated on the cribriform plate lateral to the cresta galli. Lesser wing of the sphenoid forms the upper border of the superior-orbital fissure with the greater wing of the sphenoid below. Medial end of the anterior clenoid process is grooved by the internal carotid artery as it leaves the cavernous sinus. At times middle clenoid process is connected to the anterior clenoid process by a bony bar forming the carotico clenoid foramina for the internal carotid artery. Posterior border of the lesser wing of the sphenoid is at times grooved by the sphenoparietal sinus.

Orbital surface of the lesser wing of the sphenoid is related to the orbital surface of the frontal lobe. Medially lesser wing of the sphenoid is related to anterior perforated substance. Anterior cranial fossa is separated from the middle cranial fossa by the lesser wing of the sphenoid, anterior clenoid process and the anterior limit of the sulcus chaismaticus. Frontal air sinuses may be seen in the frontal bone in the midline in front of the frontal crest. Lesser wing of the sphenoid has two roots which enclose the optic foramina near its attachment to the body of the sphenoid.

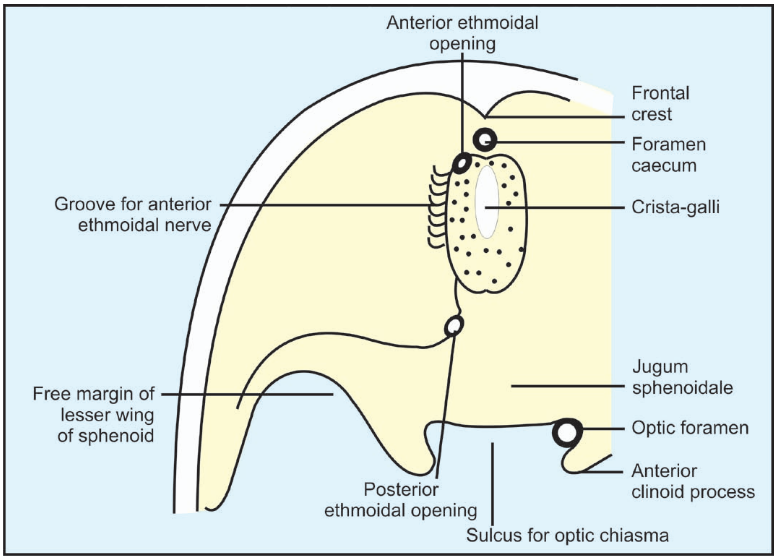



**Figure 24** Showing anterior cranial fossa

**Clinical :** Fracture of the anterior cranial fossa presents with bleeding from nose and the leakage of the cerebrospinal fluid. There can be bilateral periorbital haematoma (Panda sign) Blood collects in the upper lid as the frontal belly of the occipitofrontalis muscle has no bony attachment in front, and the subaponecrotic space is continuous with the lid space (Black eye).

**Middle Cranial Fossa (Figure 25):** It is deeper and more extensive. It is made weak and susceptible to fractures by the foramina and the fissures.

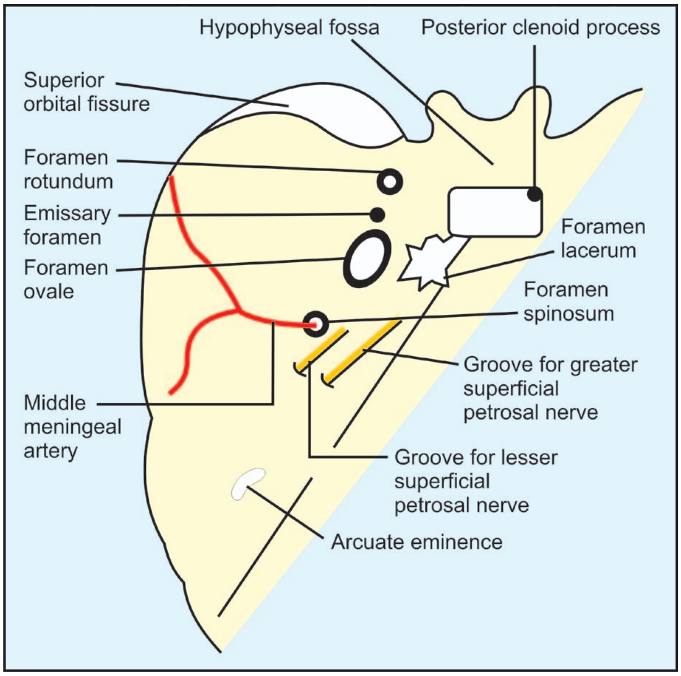



**Figure 25** Showing middle cranial fossa

**Anterior Limit of the Middle Cranial Fossa:**
1. Posterior margin of the lesser wing of the sphenoid.
2. Anterior clenoid process.
3. Sulcus chiasmaticus.

**Posterior Limit:**
1. Superior border of petrous part of temporal bone.
2. Dorsum sellae.

**Lateral Limit:**
1. Greater wing of sphenoid.
2. Squamous part of the temporal bone.
3. Parietal bone.

Middle cranial fossa lodges the temporal lobes of the cerebrum. Anteriorly it communicates with the orbit through super orbital fissure. Its lateral relation is the temporal fossa and inferior is the infratemporal fossa. Superior orbital fissure is broad medially and narrow laterally. Its lower margin presents a spine which gives attachment to common tendinus ring (ring of Zim). Following structures pass through the superior orbital fissure. Lateral part of the fissure outside the ring gives passage to the lacrimal, frontal and the trochlear nerves from lateral to medial side. The recurrent meningeal branch from the lacrimal artery to the meningeal branch of the middle meningeal artery, and the superior ophthalmic vein passes through it. Two divisions of the oculomotor, naso-cilliary and the abducent nerve pass within the ring. Nasociliary lies between the two divisions of the oculomotor nerve and the abducent is medial to the lateral rectus muscle. Medial part of the superior orbital fissure gives passage to inferior ophthalmic vein outside the tendinus ring. Foramen rotundum is placed below the medial end of the superior orbital fissure. It transmits to the maxillary nerve to the pterygopalatine fossa where it presents the pterygopalatine ganglion.

Foramen ovale is situated posterolateral to the foramen rotundum. It communicates with the infratemporal fossa, and transmits mandibular nerve, lesser superficial petrosal nerve and the accessory meningeal artery with an emissary vein. Foramen spinosum is posterolateral to the foramen ovale and transmits the middle meningeal artery and the nervous spinosus. Middle meningeal artery after coming out of the foramen spinosum runs laterally and divides into two branches anterior and the posterior. Anterior branch is placed superficially near the pterion where it is lodged in a bony canal. Foramen lacerum lies at the apex part of the temporal bone and the body of the sphenoid. Only two structures pass through this foramen

1. Meningeal branch of the ascending pharyngeal artery and
2. The emissary vein to the cavernus sinus.

Foramen lacerum is, in fact a canal and has a length. It contains internal carotid artery with sympathetic plexus around it, greater petrosal superficial nerve and the deep petrosal nerve. Greater superficial petrosal nerve joins deep petrosal nerve to form the nerve of the pterygoid canal. It leaves the foramen lacerum through its anterior wall and reaches the pterygopalatine fossa and joins the pterygopalatine ganglia. At the apex of the petrous of the temporal bone is an impression for the trigeminal ganglion. Medial end of the superior border of the petrous part of the temporal bone is notched by the roots of the trigeminal nerve.

Lateral to the trigeminal impression are the two grooves meant for greater superficial petrosal and the lesser superficial petrosal nerves. The groove for the greater superficial petrosal nerve is medial and the lesser superficial petrosal lateral. On the anterior surface of the petrous part of the temporal bone is an arcuate eminance which is produced by the anterior semicircular canal (and not by the superior semicircular canal).

Superior border of the petrous temporal bone is grooved by the superior petrosal sinus. Apex of the petrous part of the temporal bone is attached to the body of the sphenoid by means of petrosphenoid ligament. Abduscent nerve passes under the petrosphenoid ligament before its entery into the cavernus sinus.

*Petrous apex syndrome* – compression of the 6th nerve under the petrosphenoid ligament.

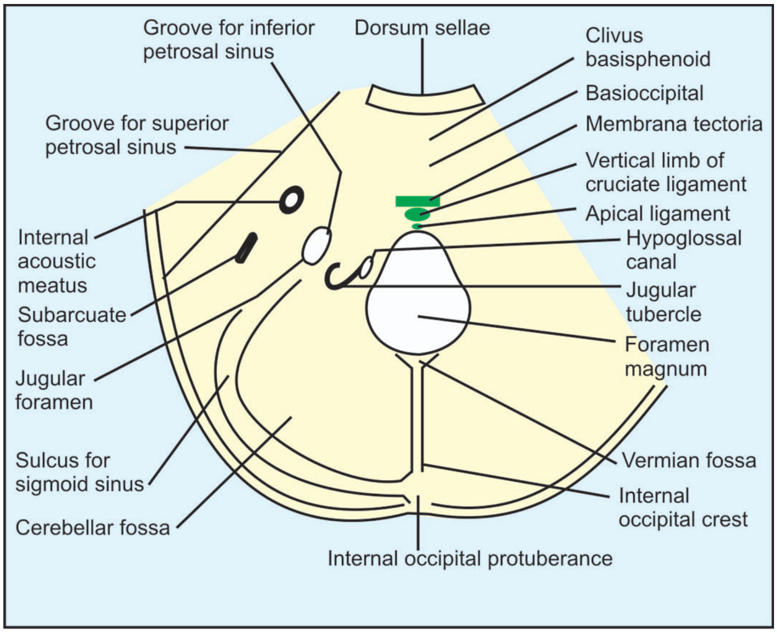
Cavernus sinuses are the paired box like intra-cranial venus sinuses situated by the side of the body of the sphenoid in the middle cranial fossa. Its limit reaches anteriorly, up to the medial end of the superior orbital fissure. Posteriorly it extends upto the apex of the petrous temporal bone, and laterally to the medial margin of the foramen ovale. Diaphragma sellae is a double fold of the dura mater covering the hypophysial fossa, which lodges the pituitary gland. It has an opening for the stalk of the pituitary in the centre. Anterior and the posterior inter-cavernus sinuses pass through tuberculum sellae and the dorsum sellae respectively. Posterior clenoid processes give attachment to the fixed margin of the tentorium cerebelli and the petrosphenoid ligament.

Lateral to the arcuate eminance the floor of the fossa is formed by tegmen tympani. It forms the osseous part of the pharyngotympanic tube, roofs of the tympanic and the mastoid antrum. Tympanic plate turns downwards to appear in the squamotympanic fissure which is divided into petro-tympanic and petro-squamous fissures.

# POSTERIOR CRANIAL FOSSA

Posterior cranial fossa is the deepest and the lowest fossa of the cranial cavity. It is separated from middle cranial fossa by the superior border of the petrous part of the temporal bone and the dorsum sellae. Its floor is formed by the sphenoid and basilar part of the occipital bones. Laterally basilar part of the occipital bone is separated from the petrous temporal bone by the petro-occipital suture. Petro-occipital suture is interrupted by the jugular foramen. Notched upper border of the jugular fossa can be seen. Posterolateral to the jugular foramen lies the groove for the sigmoid sinus which itself is the continuation of the groove for the transverse sinus. Sigmoid sinus has an important anterior relation to the tympanic antrum. Lateral to the petro-occipital suture is the internal acoustic meatus. It is separated from the internal ear by lamina cribrosa. Subarcuate fossa lies posterior to the internal acoustic meatus. It lodges the floculus of the cerebellum. The midline structures of the posterior cranial fossa, are the dorsum sellae, body of the sphenoid and the basiocciput form the clavus. It supports the pons, the medulla, basilar vertebral plexus, vertebral arteries and the basilar artery along with the pontine and medullary cisterns (Figure 26).

**Figure 26**
Showing posterior cranial fossa




The larger subarachnoid space is known as the cistern. The sloping surface in-front of the foramen magnum gives attachment to the membrana tectoria, vertical band of the cruciate ligament and the apical ligament from before backwards. In the middle of the floor of the fossa lies the foramen magnum. Anterolateral to the foramen magnum are the jugular tubercles. They are grooved by the 9th, 10th and the 11th cranial nerve. Lower down anterolateral to the foramen magnum is the anterior condylar canal. (Hypoglossal Canal). Hypoglossal nerve passes through this canal. Three fingers above the foramen magnum is the internal occipital protuberance. Internal occipital crest runs anteriorly towards the posterior margin of the foramen magnum. Just behind the foramen magnum it gets

forked to include the vernian fossa. Internal occipital crest gives attachment to the falx cerebelli. On either side of the internal occipital crest are the fossae for the cerebellar hemispheres. Internal occipital protuberance forms the site for the meeting of sinuses (confluence). Here the superior sagittal sinus turns to the right as the right transverse sinus which continues as right sigmoid sinus and further as the internal jugular vein. Right internal jugular vein is larger than the left as the superior sagittal sinus turns to the right. Superior margin of the petrous part of the temporal bone, posterior clenoid process and the lips of the groove form the transverse sinus provide attachment to the tentorium cerebelli. Free and fixed margins cross as the free margin is attached to the anterior clenoid process and fixed to the posterior clenoid process. The free margin surrounds the tentorial hiatus, which is occupied by the mid-brain.

## Pharyngeal Arches

Pharyngeal arches appear as thickenings of mesodermal core with covering of ectoderm outside and the endoderm inside in the region of pharynx. The depression between two arches outside is known as pharyngeal cleft and one on inner side is known as the pharyngeal pouch. Although they look similar to the gills of fishes, in fact they are never formed (Figure 26A).

Mesodermal element of the pharyngeal arches is derived from the mesodermal components of its own. In addition to this it receives contribution from paraxial mesoderm, lateral plate mesoderm, neural crest and the ectodermal placodes. Neural crest cells migrate to the region of the face and the pharyngeal arches, and form skeletal structures of mid-face and the neck. It must be noted that all the tissues of this region, i.e. bone, cartilage, tendon, dermis, pia and arachnoid mater, dentine and the sensory neurons are formed by them.

Neural crest cells and the ectodermal placodes give rise to neurons of 5, 7, 9 and 10th nerves. Paraxial mesoderm forms the base of cranium alongwith the small part of the occipital bone. Lateral plate mesoderm forms laryngeal cartilages such as arytenoid and cricoid. Pharyngeal arches play a major role in formation of the neck as well as the face.

In brief each arch has a muscular component having its own cranial nerve. When the muscular component migrates it carries its nerve with it. Each arch has an artery which is derived from the pharyngeal arch artery. The nerve of the first arch is mandibular, nerve of the second arch is facial while the nerve of the third arch is glossopharyngeal (Figure 26B).

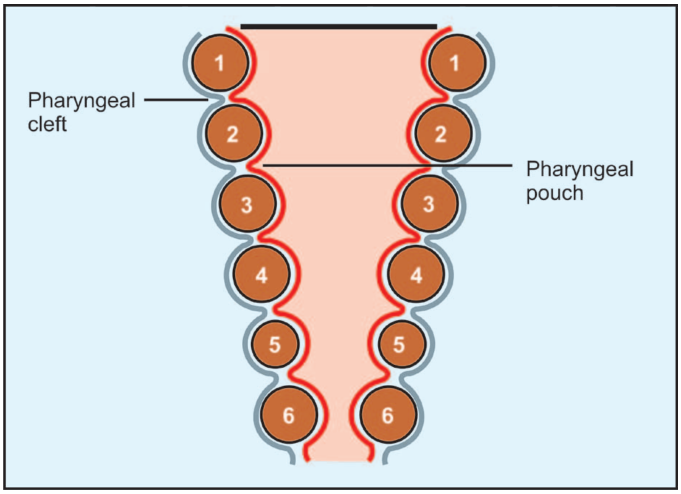



**Figure 26A** Showing pharyngeal cleft and pharyngeal pouch

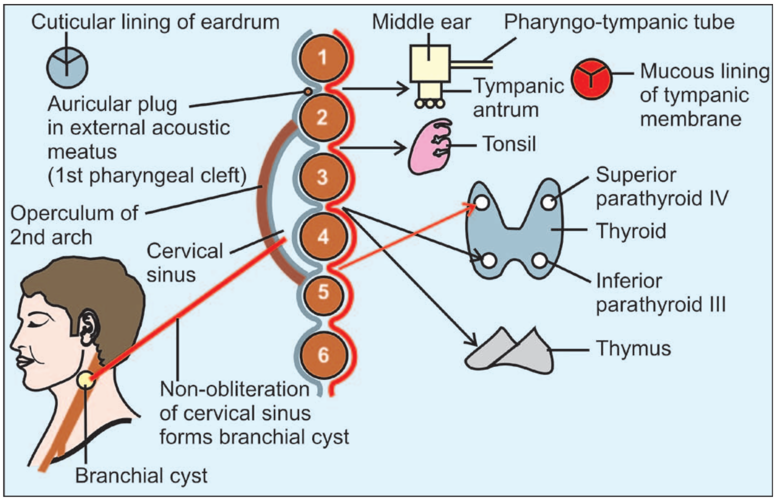



**Figure 26B** Derivatives of pharyngeal arches

**Derivatives of the pharyngeal arches are given in the following chart.**

| *No.* | *Pharyngeal arch* | *Nerve* | *Muscle* | *Bony parts* |
|---|---|---|---|---|
| 1. | Mandibular arch with maxillary and mandibular processes. | Mandibular and maxillary division of trigeminal | Muscles of mastication, i.e. temporalis, masseter, medial pterygoid, lateral pterygoid, tensor palati, tensor tympani anterior belly of digastric and mylohyoid. | Pre-maxilla, maxilla, zygomatic bone, part of the temporal bone, Meckel's cartilage, mandible, malleus, anterior ligament of malleus, incus, sphenomandibular ligament. |
| 2. | Hyoid arch (Reichert's cartilage) | Facial. | Muscles of face orbicularis oris and oculi, muscles of scalp, muscles of ear, stapedius, buccinator, platysma, posterior belley of digastric and stylohyoid. | Stapes, styloid process, stylohyoid ligament, lesser cornu of hyoid bone and upper part of the body of hyoid. |
| 3. | Third arch. | Glossopharyngeal nerve. | Styloparyngeus. | Lower part of the body of hyoid and greater cornu. |
| 4 to 6 | Fourth arch. | Superior laryngeal nerve 4th arch. | Cricothyroid muscle. | Laryngeal cartilages, thyroid cricoid, aretenoid, corniculate, cuneiform. |
| | | Vagus. | Levator palate constrictors of pharynx. | |
| | Sixth arch. | Recurrent laryngeal 6th arch. | Intrinsic muscles of larynx. | |

**Pharyngeal Pouches:** There are five paired pharyngeal pouches formed by the endodermal lining.

**First Pouch:** It forms the following:

1. Pharyngotympanic tube
2. Middle ear cavity

3. Tympanic antrum
4. Mastoid air cells and
5. Inner lining of tympanic membrane
6. *Mastoid air cells:* Which appear at fourth year of life, i.e. two years later than the appearance of the mastoid process and not in the 2nd year as stated elsewhere.

**Second Pouch :**
1. Palatine tonsil
2. Tonsillar fossa
3. Epithelial lining of tonsil and crypts.

***Note:*** Lymphoid tissue comes from mesoderm.

**Third Pharyngeal Pouch:** Dorsal bud gives rise to parathyroid III (inferior), ventral bud gives rise to thymus, i.e. thymic epithelium and Hassel's corpuscle are endodermal while the lymphatic cells are developed from haemopoietic tissue.

**Fourth Pharyngeal Pouch:** Dorsal bud gives rise to superior parathyroid.

**Fifth Pharyngeal Pouch:** Ultimobranchial body which fuses with the thyroid. Ultimobranchial body gives rist to 'C' cells. C cells of the ultimobranchial body gives rise to parafollicular cells of thyroid, which secret calcitonin, action of which is opposite to that of the parathyromone. Calcitonin deposits calcium in the bone while the parathyromone drains away the calcium from the bone.

**Pharyngeal Clefts** *First pharyngeal cleft:* Dorsal part of the first pharyngeal cleft forms the external auditory meatus.

Outer layer of the tympanic drum is also a contribution from the lining of the first pharyngeal cleft. Cellular proliferation in the floor of the canal forms ear plug which gets disintegrated and dissolved. It's persistence can cause congenital deafness.

Second pharyngeal arch grows caudally over the second and the third pharyngeal clefts enclosing an ectodermal lined space known as the cervical sinus.

Caudally the overgrowing second arch joins the epicardial ridge. Cervical sinus disappears. In case of the persistence of the cervical sinus branchial cyst is formed. Normally the cyst is located below and behind the angle of mandible. Aspirate from the branchial cyst shows cholesterol crystals which itself is diagnostic of branchial cyst.

## Development of the External Ear

External ear develops in the form of six mesenchymal hillocks, three from each, i.e. the first and the second pharyngeal arches. They fuse to form the auricle. (Pinna). Improper fusion of the hillocks leads to formation of pre-auricular sinus.

**Clinical:**
1. Branchial cyst
2. Branchial fistula
3. First arch syndrome

   There is abnormal development of the component of the first arch resulting in congenital anomalies of eyes, ears, mandible and the palate.
4. *DiGeorge syndrome:* There is hypoplasia of thymus and absence of parathyroids causing hypoparathyroidism.

## Development of Face

Face develops from five facial prominences as under:
1. Fronto-nasal prominence - one
2. Maxillary prominences – two
3. Mandibular prominences – two

Fronto-nasal prominence appears cranial to the stomodeum. Local thickenings of nasal placodes appear on either side of the fronto-nasal processes. Nasal placodes deep to form the nasal pit. Lateral to the nasal pit is the lateral nasal prominence and medial to it is the medial nasal prominence.

Maxillary prominence moves medially and meets the medial nasal prominence, thus forming the upper lip. Upper lip is formed by the two medial nasal prominences and two maxillary prominences. Maxillary prominences on either side meet in the midline burring the medial nasal prominences underneath. It must be noted that the upper lip is formed by the maxillary and the medial nasal prominences while the lateral nasal prominences have no role in the formation of upper lip. As the maxillary prominence meets the lateral nasal prominence, a groove is formed between the two. It is known as nasolacrimal groove. Solid cord of ectodermal cells grow from the floor of the groove and get buried. It gets cannalised and forms the nasolacrimal duct. Upper part of the nasolacrimal duct forms the lacrymal sac while the lower part of the duct forms nasolacrimal duct. The nasolacrimal duct runs from the medial angle of the eye to the inferior meatus of the nose. Remaining tissue of the maxillary prominence forms maxilla and the cheek.

## Development of the Nose

Bridge of the nose is formed by the frontal prominence while the medial nasal prominences form the crest and the tip of the nose. Alae of the nose come from the lateral nasal prominences.

## Foetal Skull

Foetal skull has two parts, the cover or the calvaria and the base. The ossification of the calvaria is in membrane while the base of skull gets ossified in cartilage. In cleidocranial dysostosis skull is abnormal, and clavicles are absent to an extent that the two shoulders may touch each other (Figure 16C).

1. Foetal skull is the largest component of the foetal skeleton.
   Facial skeleton constitute only 1/8th of the calvaria, as against to 1/2 in case of adults.
   Non-development of maxillae, mandible, nasal cavity, maxillary antrum and non-eruption of teeth are responsible for this disproportionate size.

**Bones of the Vault:** They are unilaminar as against bilaminar seen in adults. As the diploe is placed between the two lamini, naturally foetal skull has no diploe. It is important to remember that the diploe develop in the 4th year of life.

**Bony Prominences:** Like frontal, parietal are not prominent and glabella, superciliary arches and mastoid processes are absent.

**Fontanelle:** The bones of vaults are not completely ossified leaving interventing fibrous gaps known as fontanelles. They are 6 in numbers and are placed at four corners of parietal bone. Where two parietal bones articulate, they are the anterior and the posteior. Anterior fontanelle is rhomboid in shape because of the articulation of 4 bones, i.e. two parietals and two halves of frontal. On the other hand posteior fontanelle is triangular in shape as it is at the junction of 3 bones, i.e. two parietals and one occipital.

Frontal and mandible are in two halves. Occipital bone develops in four parts, squamous–1, condylar–2 and basilar–1. Temporal bone develops in 4 parts.

Paranasal sinuses are absent except the maxillary sinus which appears in the 4th month of intra-uterine life, it is rudimentary at birth. It is important to remember that the internal ear, tympanic cavity, mastoid antrum and three ossicles have already reached the adult size. Mastoid process is not developed leaving the facial nerve unprotected. It develops by second year of life, however the mastoid air cells develop in 6th year of life. External surface of tympanic membrane looks downwards. The germ of teeth have reached the floor of orbit at birth.

**Fontanelle:** As stated before, they are the membranous, unossified parts of the vault of skull.

**Functions of Fontanelle:**

1. They allow the overlapping of bones, reducing the size of foetal skull, helping it to pass through the birth canal.
2. They allow growth of brain. As regards the anterior fontanelle, it is of clinical, investigative and therapeutic utility.
3. Depressed fontanelle suggests state of dehydration and bulging fontanelle is suggestive of meningitis, or a state of hyperhydration.

As the superior sagittal sinus lies under the anterior fontanelle it can be used for taking blood, giving transfusion, infusion and drugs. If a needle is passed down, at the lateral angle of the anterior fontanelle, it enters ventricular cavity. All the fontanelle close earlier, except the anterior fontanelle which closed at one and half year of life.

**Postnatal Growth of Skull:** Vault grows at a faster rate during 1st year of life and it reaches its adult size in 7th year of life. It is the growth and obliteration of sutural joint which decides the length and breath of skull.

Following sutures play an important role in deciding it.

1. Sagittal suture
   Sutures around the greater wing of sphenoid
   Petro-occipital and
   Occipito-mastoid sutures.

Height of the skull is due to growth at pterion and asterion, while the anteroposterior length depends upon coronal and lambdoidal sutures. Growth of the base of the skull is dependant on three cartilaginous joints.

Obliteration of sutures of the vault of skull begins from inside and reach outside. The obliteration at inner aspect of the skull begins at the age of 45 and reaches outside at the age of 50-55. In old age, skull is reduced in size due to loss of teeth and changes in the mandible. Angle of the mandible becomes obtuse from right angle (Obtuse angle is seen with the easy chair while the upright angle is seen with the chair of a dining table).

**Wormian Bones** They are small in size and irregular in shapes, commonly found at the fontanelle.

Sex differenes between the male and female are not seen before puberty. Skull of the male is larger with greater capacity. Now it is established

that the capacity of cranial cavity is not a criteria for intelligence. We find women as intelligent as men or even more.

Forehead in case of male is sloping while in case of female, it is vertical. Frontal and parietal eminences are prominent in female. In males, chin is bigger and prominent due to projection of mandible.

*Note:* Wormian bones are rarely seen at bregma and are common at lambda, asterion, pterion. The wormian bones at anterior fontanelle or bregma is known as OS Kerckring! In hydrocephalus, wormian bones are more.

**Cephalic Index:** $\frac{\text{Maximum breadth}}{\text{Maximum length}} \times 100 = \text{Cephalic index}$

# CERVICAL FASCIA

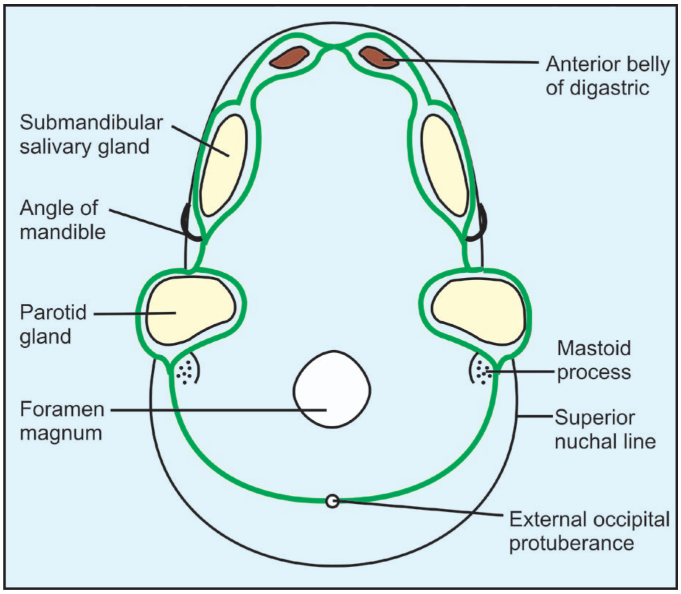
The study of the fascia colli and spaces formed are surgically important. Cervical fascia is the deep fascia of the neck arranged in four different components. One which surrounds the neck like the collar is known as investing layer which lies in front of the vertebral region is known as prevertebral fascia and the one lies in front of the trachea and surrounds the thyroid gland is called the pretracheal layer. The special condensation of tissue around the common carotid artery, internal jugular vein and the vagus nerve is known as the carotid sheath.

**Investing Layer:** This layer forms a surface cover for the structures of the neck. It should be studied at three different levels.

a. At the base of skull.
b. In the neck.
c. At the root of the neck.

a. *At the base of skull (Figure 27):* The investing layer of fascia is attached to the external occipital protuberance, superior nuchal line, the mastoid process the mandible and the symphysis menti. The covering of the parotid gland and the masseter muscle is known as paratido-messetric fascia. It is attached to the zygomatic arch. It is tough and is supplied by the great auricular nerve which also supplies the temporal region. Fluctuations can not be elicited in case of parotid abscess due to the tough fascia over it. Due to innervation by the great auricular nerve swelling or abscess of the parotid region presents with pain in the temporal region (Referred pain).

**Figure 27**
Showing attachment of investing layer at the base of skull



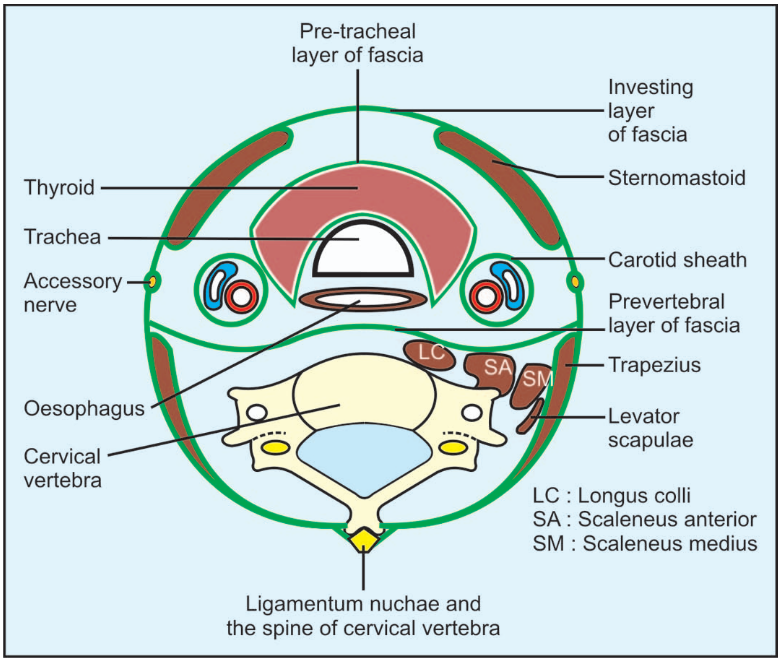

At the base of the skull the investing layer of deep fascia splits thrice 1. To enclose the parotid gland; 2. The submandibular salivary gland and; 3. The anterior belly of diagastric muscle.

Deep part of the investing layer of cervical fascia under the parotid forms a specialized condensation between the tip of the styloid process and the angle of mandible. It is known as stylomandibular ligament. It separates the parotid gland from the submandibular salivary gland. There

is another condensation running from the spine of the sphenoid to the lingula of the mandible known as sphenomandibular ligament. It is pierced by the nerve to mylohyoid muscle and the accompanying vessels.

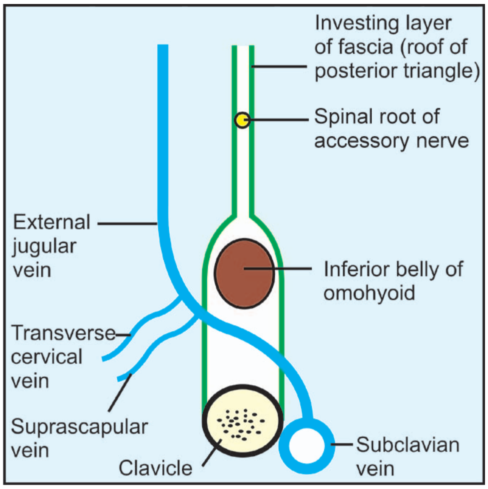
b. *In the neck (Figure 28):* It starts from the spines of cervical vertebrae and the ligamentum nuchae posteriorly. As it encircles the neck it splits into two layer to enclose the trapezious muscle, spinal accessory nerve and the sternomastoid muscle. Between the trapezious and sternomastoid it forms the roof of the posterior triangle. Spinal accessory nerve runs in the roof of the posterior triangle and disappears under the anterior border of the trapezius 5 cm above the clavicle. Between the sternomastoids investing layer of the fascia forms the roof of the anterior triangle of the neck. This is the story of transverse tracing of the investing layer in the neck.

**Figure 28** Showing general arrangement of cervical fascia




**At the Roof of the Posterior Triangle (Figures 29 and 30):** Running from the superior nuchal line it encloses spinal root of the accessory nerve and lower down the inferior belly of omohyoid. Its two layers get attached to the anterior and the posterior border of the clavicle. The space thus formed is known as omohyoid interspace. It contains inferior belly and omohyoid muscle, external jugular vein, its tributaries and the supraclavicular nerves. This space is also known as supra clavicular space.

**Figure 29** Showing arrangement of deep fascia of roof of posterior triangle



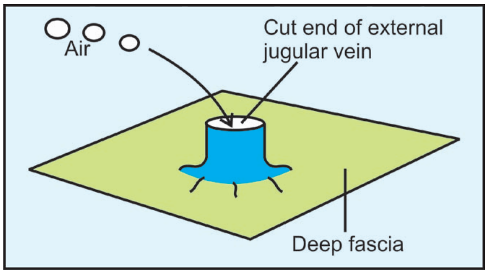



**Figure 30**
Showing air embolism of external jugular vein
Note: The fascial pull on the wall of the vein by the deep fascia

**Vertical Tracing in the Midline of the Neck (Figures 31 and 32):** It is attached to the symphysis menti and the hyoid bone. It splits into two layers above the manubrium sterni and gets attached to the manubrium sterni to its anterior and posterior borders. The space formed by the two layers above the sternum is called as the suprasternal space of Burn. It contains sternal head of sternomastoid muscle, anterior jugular veins, anterior jugular arch, lymph node and the inter-clavicular ligament.

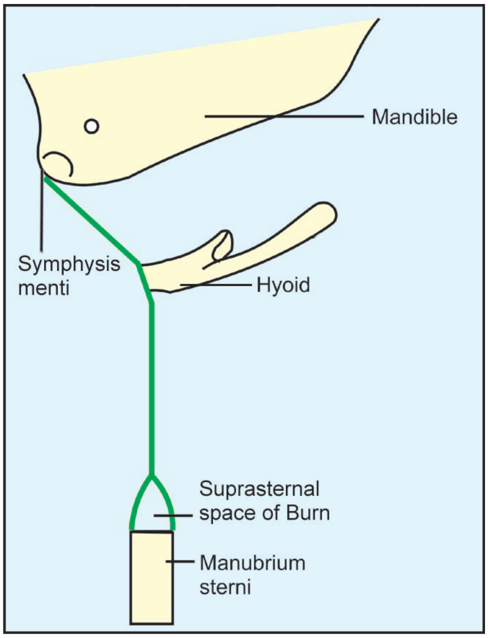



**Figure 31**
Showing anterior midline tracing of investing layer of deep fascia

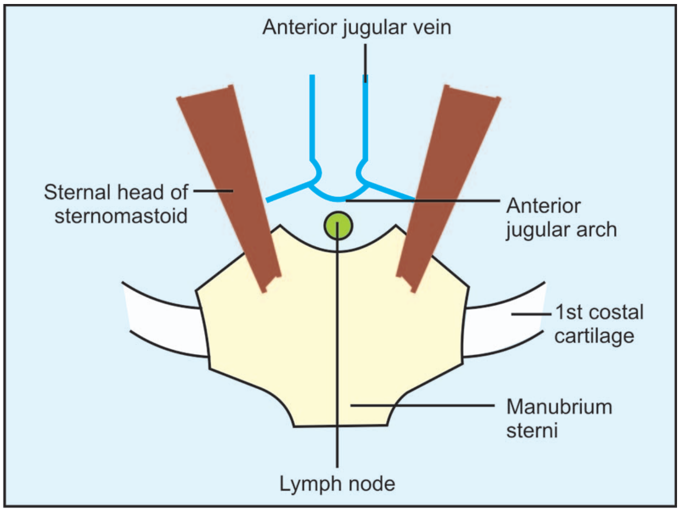



**Figure 32**
Showing contents of suprasternal space of Burn

c. *At the root of the neck (Figure 33):* Its attachment at the root of neck is a continuous line, attached to the spine of scapula, the acromion, clavicle and the sternum.

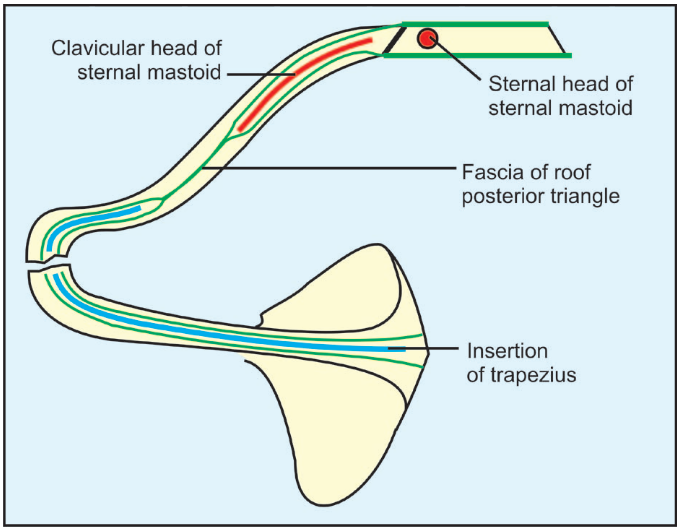



**Figure 33**
Showing attachment of investing layer of deep fascia at the root of the neck

**Clinical :** External jugular vein, pierces the investing layer of the deep fascia of the neck above the clavicle where it's walls are firmly attached to the fascia. In case of injury to the vein proximally it doesn't collapse due to pull of the fascia on its wall. Atmospheric air enters the vein leading to an air embolism, which may prove fatal (Venous air embolism).

**Pretracheal Layer (Figure 34):** It is attached to the hyoid bone in the midline and the thyroid cartilage along the oblique line. It encloses the thyroid gland and forms the fascial capsule of the gland. From the back of the thyroid gland, a special thickening of the fascia runs to the cricoid cartilage. It is known as the suspensary ligament of the Berry. The levator glanduli thyroidae also helps in moving the thyroid swelling during deglutition. Lower down the pretracheal layer of the fascia enters the superior mediastinum and gets fused to the fibrous coats of the aorta and pulmonary trunk. During clinical examination the upward movement of the neck swelling is suggestive of thyroid swelling.

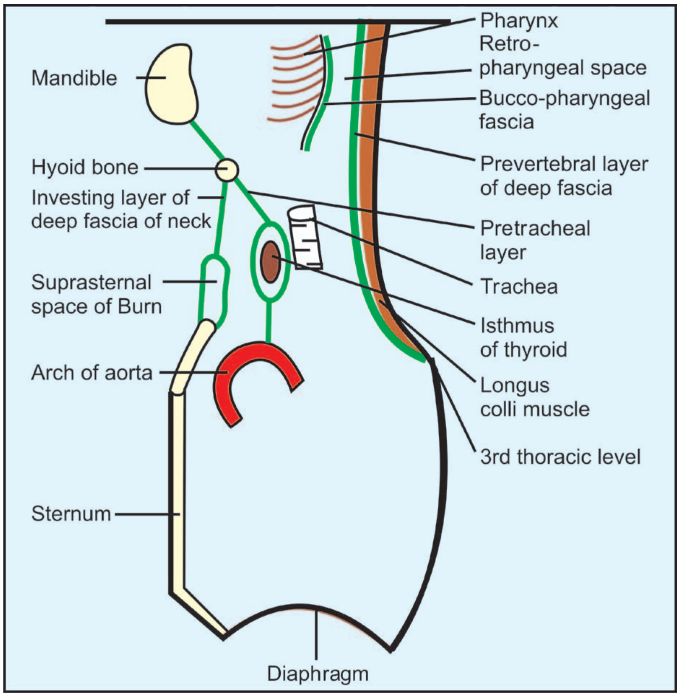



**Figure 34**
Showing arrangement of fascia of neck and tissue spaces in thorax (Highly schematic)

**Prevertebral Layer:** Prevertebral layer is the tough membrane situated in front of the prevertebral muscles i.e. longus colli, scalenus anterior, middle and the scalenus posterior muscles. It is attached to the base of the skull above and the third thoracic vertebra below, which is the lowest limit of longus colli muscle. Laterally it covers the muscles of the floor of the posterior triangle. As the subclavian artery lies behind the prevertebral fascia, it takes the sheath along with it, between the scalenus anterior and the scalenus medius muscles. It is known as the axillary sheath, as it surrounds the axillary artery and the part of the brachial plexus. Axillary vein is kept outside the axillary sheath to allow its dilatation during the increased venous return. Pus or blood may reach the axilla through the axillary sheath from the prevertebral space. The phrenic nerve lies deep to prevertebral fascia and is away from the edge of the surgeons knife during surgery at the root of the neck during block dissection of the cervical nodes.

**Carotid Sheath:** It is the condensation of the areolar tissue surrounding the carotid arteries, internal jugular vein and vagus nerve. Part of the sheath over the internal jugular vein is thin to allow dilatation of vein during increased venous return. The thin layer over the vein is due to the weaker pulsations of the vein. Carotid sheath is attached to the base of the skull above and to the aortic arch below. Posterior to the carotid sheath are the prevertebral fascia and the sympathetic chain. Carotid sheath is attached to the anterior border of the sternomastoid muscle. The space in between the prevertebral fascia posteriorly and the carotid sheath anteriorly is occupied by the loose areolar tissue which permits the infection to go freely behind the carotid sheath.

**The Tissue Spaces of Neck:**

1. Space behind the prevertebral fascia.
2. Space in front of prevertebral fascia.
3. Space in front of pretracheal fascia.

**Space behind the Prevertebral Fascia:** This space lies between the longus colli muscles and the prevertebral fascia. It ends at lower border of the third thoracic vertebra with the muscle. An abscess from cervical vertebrae can travel in this space up to the third thoracic vertebra and not beyond, unless it perforates the fascia.

**Space in Front of Prevertebral Fascia:** This space extends from the base of the skull above to the diaphragm below. Part of the space behind the pharynx is known as retropharyngeal space, which is surgically important. It has a lateral communication with the posterior triangle of the neck behind the carotid sheath. There is every possibility of pus descending into the superior and the posterior mediastinum, however the pathological adhesions prevent it.

Retropharyngeal space contains loose areolar tissue which allows movements of the pharynx during deglutition. It is described as the pharyngeal bursa in many texts. However, the name bursa is a misnomer. As per the definition bursa is a closed bag lined by epithelium containing fluid. Therefore, the so called retropharyngeal bursa can be described as the cushion of loose areolar tissue for the pharynx (Pharyngeal pillow).

**Parapharyngeal Space (Figure 35):** Parapharyngeal space is the cone shaped potential space, with base at the base of the skull and the apex pointing downwards towards the hyoid bone, near the angle of the mandible. Infection and formation of an abscess in the space is seen after removal of the tonsil, done under the local anaesthesia. Clinical picture is similar to quinsy (peritonsillar abscess). However, the trismus and the swelling over the lower part of the parotid are absent in quinsy. The space contains carotid sheath and may cause thrombophlebitis of the internal jugular vein and erosion of the internal

carotid artery leading to death. The abscess under tension may burst in the external auditory meatus through the plates of cartilages and the patient is saved. The credit for saving the life of the patient rightly goes to the nature and not to the doctor.

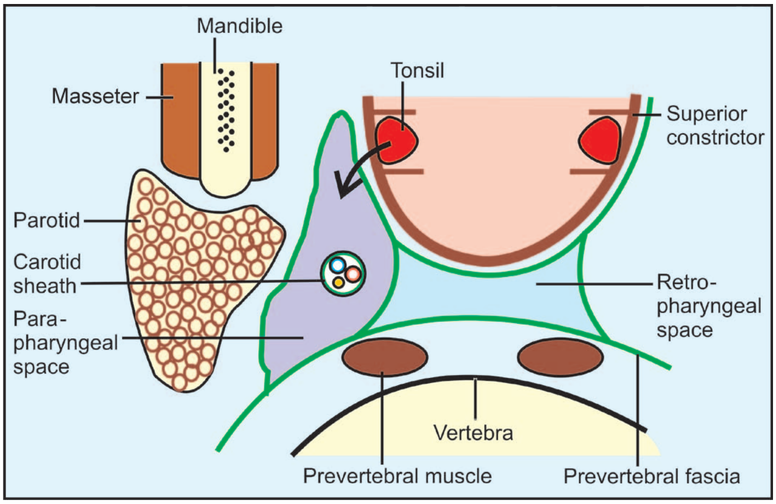



**Figure 35** Showing para-pharyngeal space. Please note black arrow showing the source of infection of parapharyngeal space. Internal jugular vein and common carotid artery are in the middle of space

# CERVICAL PLEXUS

**Formation:** Anterior primary rami of the upper four cervical nerves form connections in the form of loops. All the rami receive the grey rami from the superior cervical sympathetic ganglion (Figures 36 and 37)

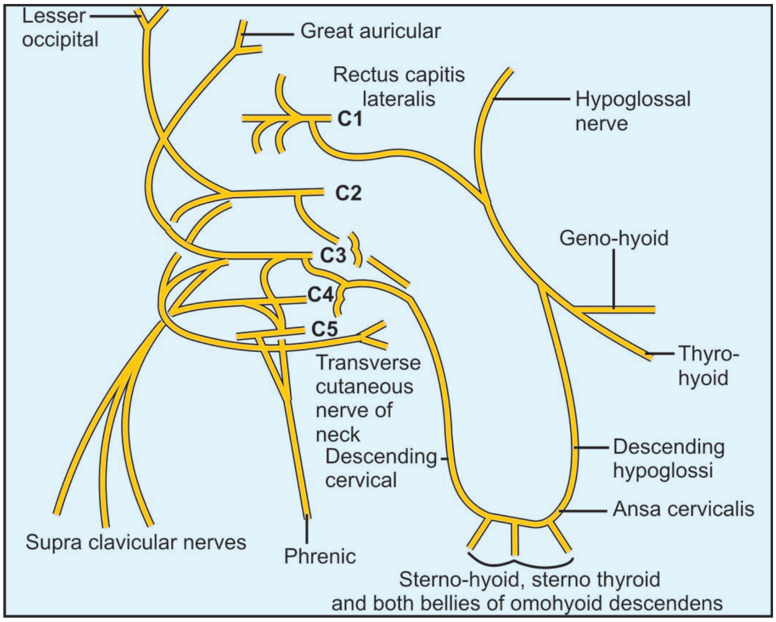



**Figure 36** Showing formation of cervical plexus

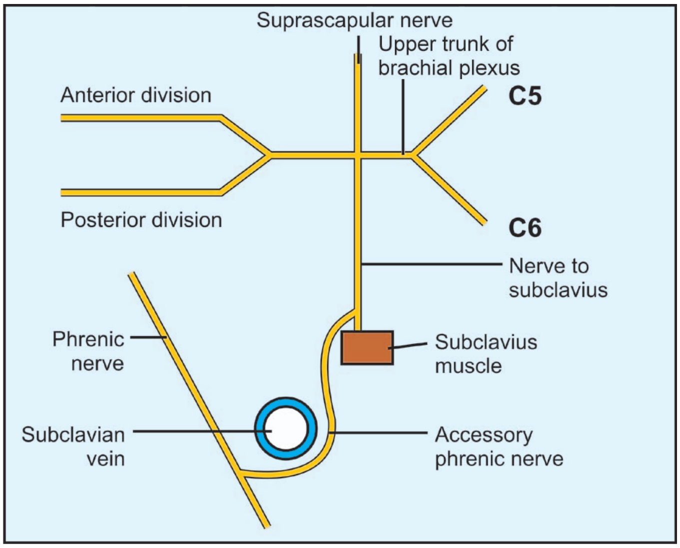



**Figure 37** Showing accessory phrenic nerve

**Situation :** It lies on the scalenus medius muscle under the prevertebral fascia, covered by longus capitis and the sternomastoid muscles. Its branches pierce the prevertebral fascia along the posterior border of the sternomastoid muscle. During block dissection of the lymph nodes of the neck for a malignant disease the cervical plexus remains safe from the edge of knife as it lies behind the prevertebral fascia.

**Branches:** Its branches can be grouped under the following heads.

**Superficial** C2-Lesser occipital.

**Branches:** C2 and C3 – Great auricular.
C3 and C4 – Supraclavicular.

**Communicating Branches:** They are with sympathetic, vagus and the hypoglossal nerves. It must be remembered that C1 joins the hypoglossal nerve and gives branch to the meninges and supply the muscles, geniohyoid and the thyrohyoid.

**Deep Branches:** They are arranged into two groups, namely the medial and lateral.

**Medial Branches:** They are

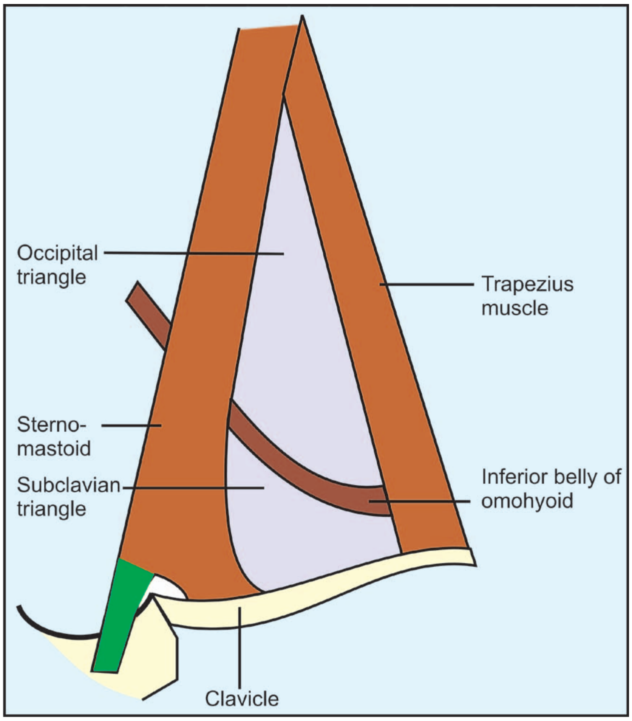
1. Nerve to rectus capitis anterior,
2. Rectus capitis lateralis,
3. Longus cervicis,
4. Longus capitis, and
5. The inferior limb of the ansa cervicalis.

The most important branch of the plexus is the phrenic nerve which is the motor nerve to the respiratory diaphragm.

**Lesser Occipital:** Lesser occipital nerve runs along the posterior border of the sternomastoid and hooks the spinal root of the accessory nerve, at the junction of the upper third and the middle third of the posterior border of the sternomastoid. This point is known as the nerve point. For giving cervical plexus block, the anaesthetist selects this site for injecting the local anaesthetic agent.

**Great Auricular Nerve (Figure 38):** Great auricular nerve lies over the sternomastoid muscle. It supplies the skin of the parotid region and the parotid fascia. It supplies the major part of the cranial surface of the auricle and the lower part of the external surface of the auricle below the external auditory meatus. It arises from the 2nd and 3rd cervical rami and hooks the posterior border of the sternomastoid muscle, perforates the deep fascia and runs upwards under cover of the platysma in company with the external jugular vein. Near the parotid gland it divides into the anterior and posterior branches. Anterior branch supplies the skin of the parotid region and the lobule of the auricle. It has the communicating branch with the facial nerve. Posterior branch supplies the skin over the mastoid and the major part of the cranial surface of the auricle.

**Figure 38** Showing posterior triangle and its two divisions made by the inferior belly of omohyoid



**Anterior Cutaneous Nerve of Neck:** It hooks the posterior border of sternomastoid muscle and runs transversely and breaks up into number of branches to supply the midline region of the neck. It communicates with the cervical branch of the facial nerve above. This communication lies in-front of the external carotid artery.

**Supraclavicular Nerves (C3 and C4):** They are divided into the three groups namely the medial intermediate and the lateral. Medial one crosses the sternal end of clavicle and supplies the area of skin upto the level of the second costal cartilage. It also supplies the sternoclavicular joint. Lateral group crosses the acromial end of the clavicle and supplies the area of skin over the upper half of the deltoid muscle. Middle one passes through the clavicle proper.

**Deep Branches:**

1. *Longus capitis*
   Longus cervicis.
   Scalaneus anterior, medius
   and the posterior
   } All are segmentally supplied.
2. *Loop from C1 to the 12th cranial nerves eq. hypoglossal :*
   It is gives meningeal branch and joins the hypoglossal nerve which supplies the geniohyoid and the thyrohyoid muscles. It gives descendents hypoglossi which joins the descendents cervicalis to form the loop which is called ansa hypoglossi.
3. C2 and C3 to sternomastoid muscle
   C3 and C4 to trapezius muscle
   } They are proprioceptive.
4. *Descendens cervicalis:* C2 and C3 – It descends over the internal jugular vein and joins the descendens hypoglossi to form loop. (Ansa hypoglossi).

   *Phrenic:* Phrenic is the most important branch of the cervical plexus. At present one must remember that it is formed by C4 with insignificant contributions from C3 and C5. It is the mixed nerve having motor and sensory fibers are in proportion of 2:1. It is formed on the scalaneus medius at the lateral border of the scalenus anterior. It gradually descends over the scalenus anterior muscle from lateral to medial side, lying little lateral to the ascending cervical branch of the inferior thyroid artery. It lies behind the prevertebral fascia and is crossed by transverse cervical and suprascapular arteries. Thoracic duct lies in front of the left phrenic nerve. The right phrenic nerve lies on the scalenus anterior muscle and does not cross the first of the subclavian artery, while the left phrenic nerve leaves the scalenus anterior muscle earlier and crosses the first part of the left subclavian artery. The phrenic nerves have the tendency to swing to the right. Similar is the tendency of the internal jugular veins at the root of the neck. Both the internal jugular veins tend to go to the right, as a result the left internal jugular vein overlaps the left common carotid artery and the right internal jugular vein goes to the right, away from the right common carotid artery.

**Note:** The tendancy of swinging to the right is not limited to the phrenic nerves and the internal jugular veins, but is also aquired by the subclavian arteries too. Due to its love for the right, the right thyrocervical trunk arises from the second part of the right subclavian artery instead of the first.

**Accessory Phrenic Nerve:** Phrenic nerve is formed mainly by C-4 and has the contribution from 3 and 5. Fifth segment of the phrenic goes to nerve to subclavious muscle. It leaves the nerve to the subclavious muscle as an accessory phrenic nerve and joins the phrenic after hooking the subclavian vein. It is known as ansa subclavia. During phrenic nerve pull subclavian vein can get damaged.

**History of Phrenic Nerve Avulsion:** Before advent of the modern drugs of treatment of pulmonary tuberculosis was as under:

Fresh Air
Good Diet
Rest to the body and
Rest to the Parts.

In order to give rest to the part of the lung having tubercular lesion diaphragm was paralysed by the technique of the phrenic nerve avulsion. Paralysed diaphragm goes up in the position of rest and gets stuck to the base of the lung giving compulsory rest to it. Similarly pneumoperitoneum was practiced to push the diaphragm up against the base of the lung by introducing an air in the peritoneal cavity.

However, today this is the part of the history of medicine.

# POSTERIOR TRIANGLE

It is situated at the side of the neck like a leaf and is not in one plane. It lies between the sternomastoid and trapezius muscles and its base is formed by the middle third of the clavical below. Apex of the triangle is formed by the meeting of the trapezius and the sternomastoid muscles at the superior nuchal line (Figure 38).

It has the floor, roof, base, apex, anterior and the posterior borders and the contents.

However, the triangle is divided into two by the inferior belly of omohyoid. Subclavian triangle lies below and the occipital triangle above the inferior belly of omohyoid.

The differences of contents of the two triangle are separately mentioned later as it is easier to remember the contents of the posterior triangle as a whole rather than partwise.

**Base:** Base is formed by the middle third of the clavicle.

**Apex:** Apex is the meeting point of sternomastoid and the trapezius muscles at the superior nuchal line.

**Anterior Border:** Its anterior border is formed by the posterior border of the sternomastoid muscles.

**Posterior Border:** Posterior border of the triangle is formed by the anterior border of the trapezius muscle.

**Floor (Figure 39):** Following muscles form the floor below upwards.

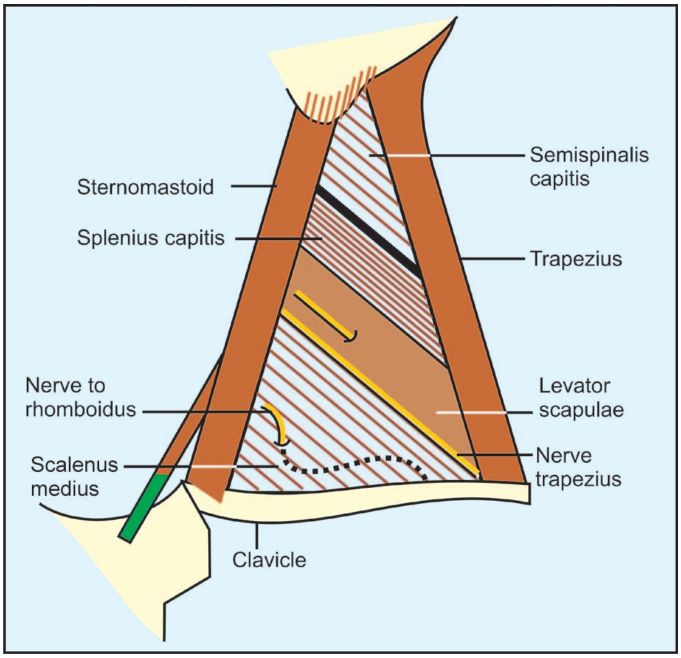



**Figure 39** Showing muscles of the floor of posterior triangle of neck

1. Scalenus medius.
2. Levator scapulae.
3. Splenius capitis.
4. Semispinalis capitis (some times).

**Roof:** Roof is formed by the investing layer of deep cervical fascia. The spinal root of the accessory nerve runs over the levator scapulae muscle enclosed in the fascia of the roof. Roof is pierced by the cutaneous nerves, external

jugular vein and its tributaries. Platysma covers the anteroinferior part of the roof.

**Contents (Figure 40):**

1. *Muscle:* Inferior belly of omohyoid.
2. *Nerves:*
   a. Part of the brachial plexus.
   b. 11th nerve
   c. Cutaneous branches of cervical plexus.
   d. Nerve to subclavius
   e. Suprascapular nerve
   f. Nerve to rhomboidius and greater occipital nerve.
   g. Third and fourth cervical nerves to the trapezius. They are proprieceptive.
3. *Arteries:*
   a. Third part of subclavian artery.
   b. Transverse cervical and supra scapular arteries.
   c. Occipital artery (At the Apex)
4. *Veins:*
   a. Subclavian vein.
   b. External jugular vein and its tributaries.
5. *Lymph nodes:*

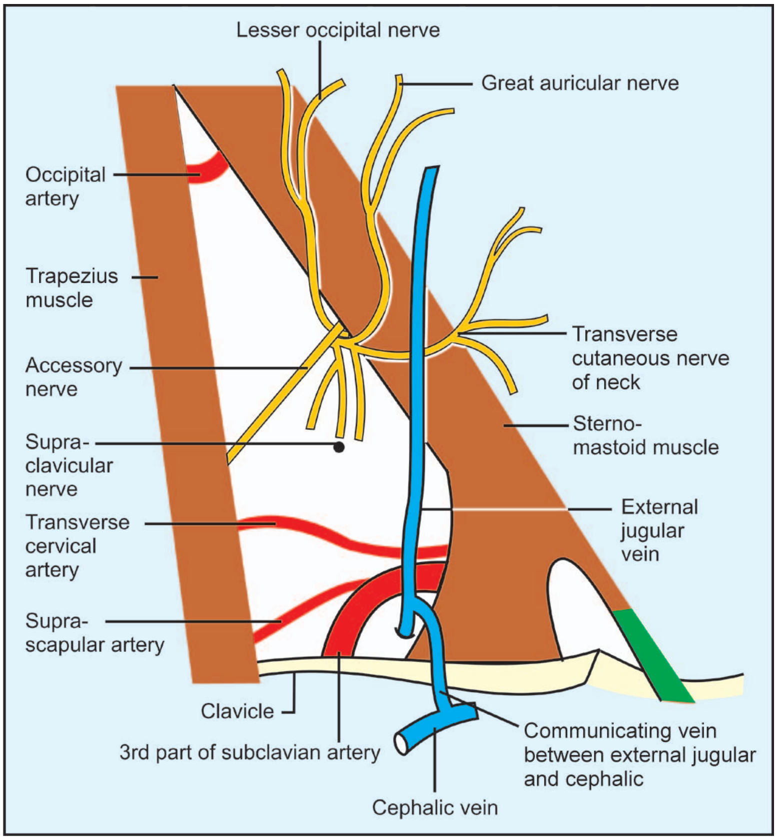



**Figure 40** Showing arteries and nerves of posterior triangle of neck. Please note connecting channel between cephalic and external jugular vein across the clavicle

**Lymph Nodes of Posterior Triangle (Figure 41):**

1. Occipital at the apex in company with the occipital artery.
2. Along the posterior border of the sternomastoid muscle.
3. Along the accessory nerve. They are important as in tubercular adenitis, they get enlarged and distort the course of the accessory nerve.
4. *Supraclavicular lymph nodes:* They occupy the subclavian triangle. Left supraclavicular nodes are important as they enlarge in the carcinoma of the stomach (Troisier's sign).

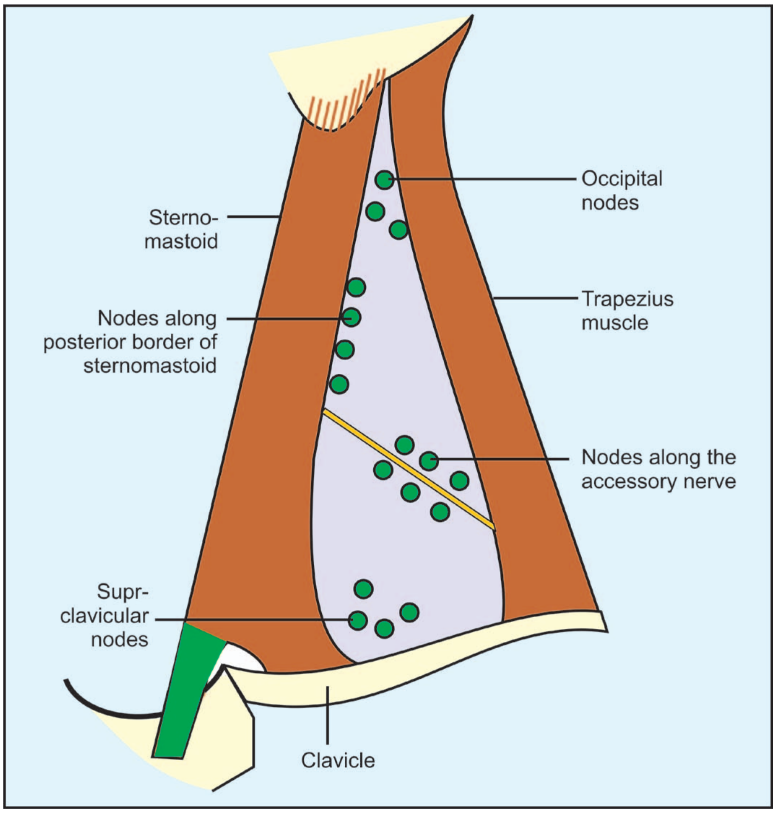



**Figure 41** Showing lymph nodes of posterior triangle of neck

**External Jugular Vein (Figures 42A and B):** External jugular vein is formed by the union of posterior division of retromandibular and the posterior aricular veins, at the the lower pole of parotid gland. It runs on the sternomastoid muscle and is directed downwards and laterally. Lower down it lies on the anteroinferior part of the roof of the posterior traingle. It pierces the deep fascia of the roof of the posterior triangle passes infront of the third part of subclavian artery and joins the subclavian vein behind the clavicle. The margins of the external jugular vein are firmly fixed to the deep fascia. In case the vein is cut proximal to the entry into the deep fascia the walls of the vein do not collapse. As a result air enters the open end of the vein, leading to the air embolism. In an effort to close the opening the deep fascia around opening is cut. External jugular vein is joined by two tributaries namely the transverse cervical, suprascapular and the anterior jugular veins in the posterior triangle. External jugular vein throughout its course lies under the platysma.

**Eleventh Nerve (Figure 40):** Eleventh nerve is known as the accessory nerve. It is the spinal part of the accessory which is seen in the posterior triangle. It contains fibres from the cervical roots. The nerve appears at the posterior border of sternomastoid muscle and runs along the roof of the posterior triangle to disappear under the anterior border of the trapezius muscle 5 cm above the clavicle. In the posterior triangle it runs on the levator scapulae muscle enclosed in fascial root. It is accompanied by small group of lymph nodes which have already been discussed (Figure 41).

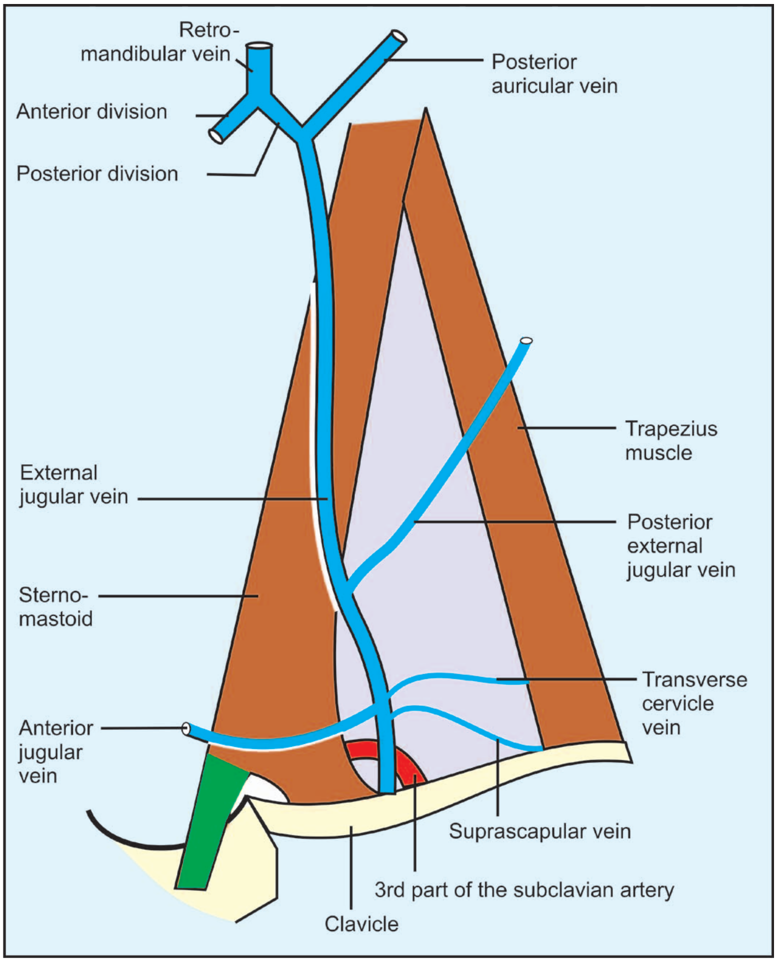



**Figure 42A**
Showing formation tributaries and relations of external jugular vein

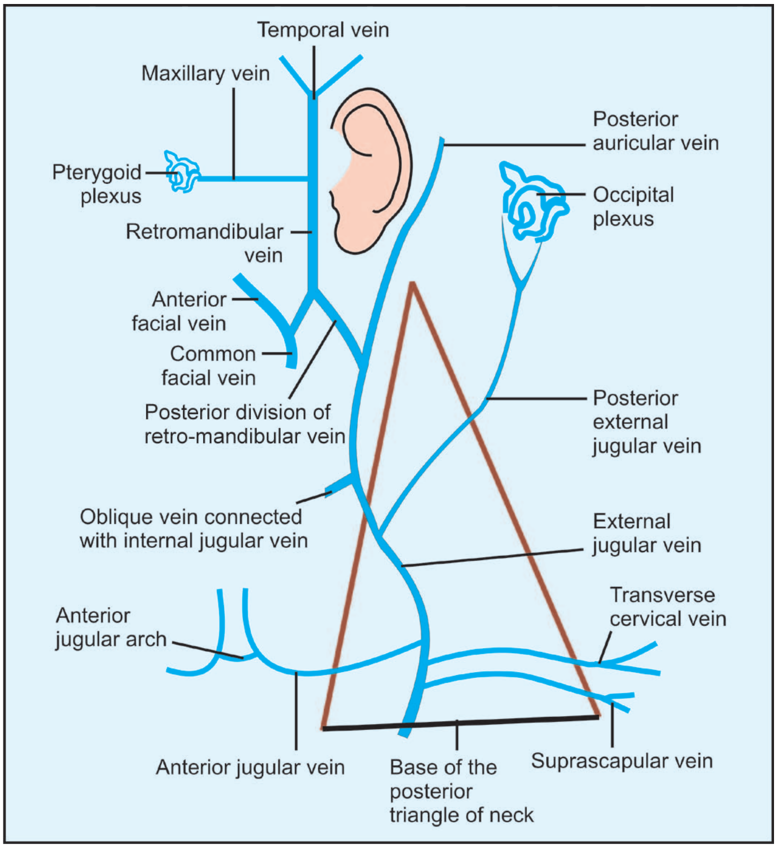



**Figure 42B**
Showing superficial veins of face and neck

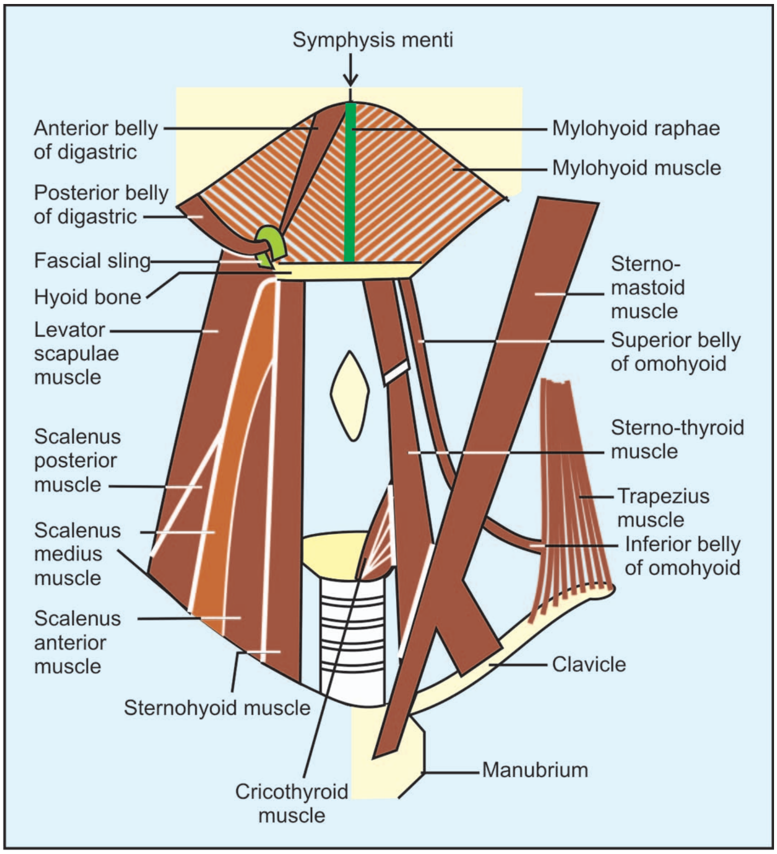



**Figure 43** Showing muscles of front of neck including the sternomastoid and trapezius muscle

The occipital and the subclavian triangles are mentioned below:

| *Occipital triangle* | *Subclavian triangle* |
|---|---|
| 1. **Lower limit:** Inferior belly of omohyoid. | **Upper limit:** Inferior belly of omohyoid. |
| 2. **Floor:** From above downwards<br>a. Splenius capitis<br>b. Levator scapulae<br>c. Scalenus medius | **Floor:**<br>a. First rib<br>b. Scalenus medius<br>c. First digitations of serratus anterior muscle. |
| 3. **Nerves:**<br>Spinal root of accessory<br>Four cutaneous nerves<br>a. Lesser occipital<br>b. Great auricular<br>c. Anterior cutaneous nerve of neck.<br>d. Supraclavicular. | **Nerves:**<br>Three trunks of the brachial plexus.<br>a. Supraclavicular.<br>b. Nerve to subclavius.<br>c. Nerve to serratus anterior. |
| 4. **Muscular branches:**<br>a. Levator scapulae<br>b. Trapezius<br>c. Rhomboidius<br>d. Upper trunk of the brachial plexus. | |
| 5. **Arteries:**<br>a. Transverse cervical artery.<br>b. Occipital artery. | **Arteries:**<br>a. Third part of the subclavian artery.<br>b. Transverse cervical artery.<br>c. Suprascapular arteries. |
| **Veins:**<br>a. Posterior external jugular vein. | **Veins:**<br>a. External jugular vein and its tributaries, i.e. transverse cervical and<br>b. Suprascapular<br>c. Subclavian vein at times. |
| **Lymph nodes:**<br>a. At the apex with the occipital artery.<br>b. Along the posterior border of the sternomastoid muscle.<br>c. Along the spinal root of the accessory nerve. | **Lymph nodes:**<br>a. Supraclavicular nodes. |

**Scalenus Anterior Muscle (Figure 44):** Scalenus anterior muscle is the key muscle of the root of the neck.

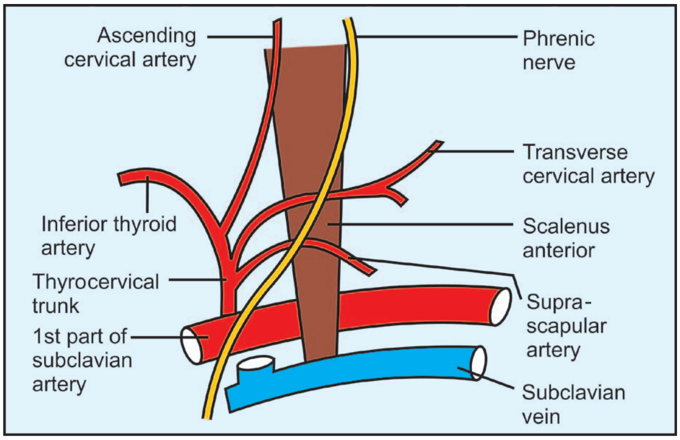



**Figure 44** Showing anterior relations scalenus anterior muscle of the left. Please note that thoracic duct is omitted for clarity

**Origin:** It takes origin from the transverse processes of the third, fourth, fifth and sixth cervical vertebrae (typical cervical vertebrae)

**Insertion (Figures 45A and B):** The muscle is inserted into the small tubercle at the medial border of the first rib which is known as scalene tubercle.

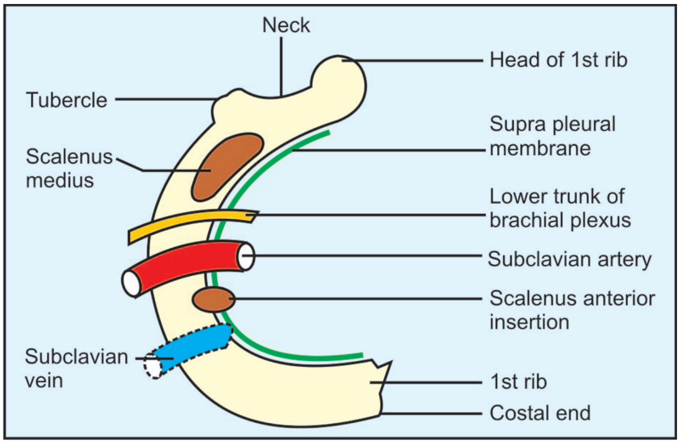



**Figure 45A** Showing posterior relations of scalenus anterior muscle as viewed on superior surface of 1st rib

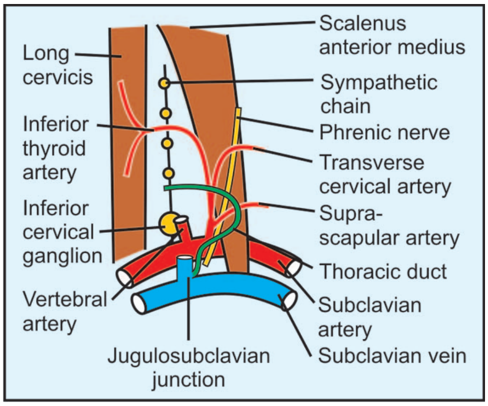



**Figure 45B** Showing the triangular interval medial to the scalenus anterior muscle

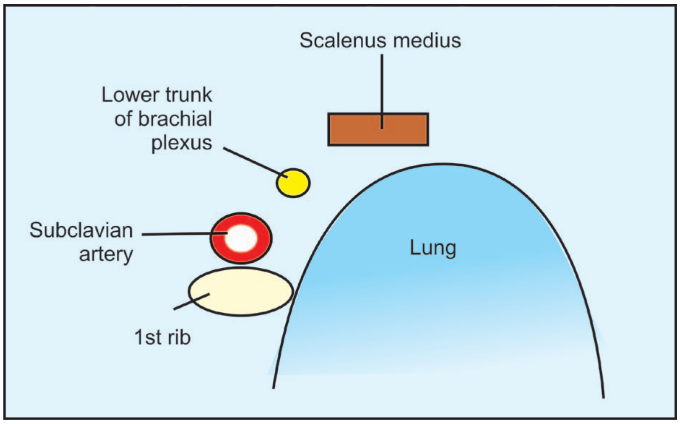
**Relations of the Scalenus Anterior:** Following structures are in front of the muscle above downwards.

1. Phrenic nerve (It is virtually plastered to the anterior surface of the muscle by the pre-vertebral fascia).
2. Inferior belly of omohyoid.

3. Transverse cervical artery.
4. Suprascapular artery.
5. Subclavian vein.
6. Sternomastoid muscle forms the cover for all the structures including the scalenus anterior.
7. Clavicle and subclavius muscle.

**Third Part of the Subclavian Artery (Figure 46):** Third part of the subclavian artery lies at the antero-inferior angle of the posterior triangle. However, its distal part is under the clavicle. It is crossed by the external jugular vein from the front.

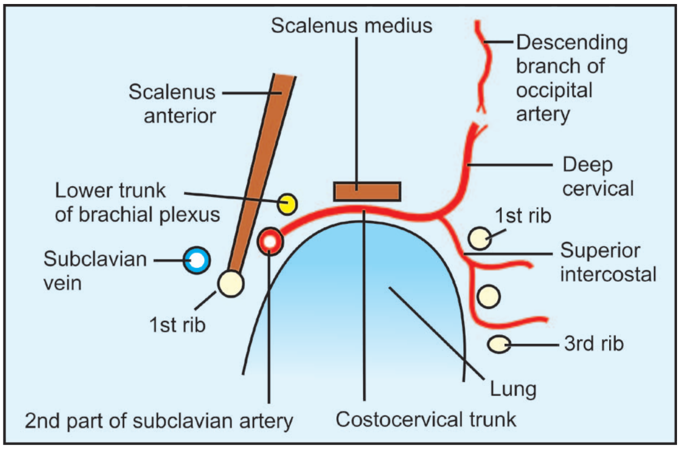
**Figure 46** Showing postero-inferior relations of third part of subclavian artery




## Relations of the Third Part of the Subclavian Arteries

**Superficial Relations (Figure 47):** Skin, superficial fascia, platysma, external jugular vein, suprascapular nerves form the superficial relations of the third part of the subclavian artery.

**Figure 47** Relations of second part of subclavian artery (diagrammatic)




**Posteroinferior Relations:** Cervical pleura, scalenus medius muscle, the lower trunk of brachial plexus and the first rib form the posteroinferior relations of the third part of the subclavian artery.

**Clinical:**

1. *Subclavian steal syndrome:* It is seen in obstruction of the first part of the subclavian artery proximal to the origin of the vertebral. In this syndrome blood is drawn into the vertebral artery of the affected side from the veretebral artery of the normal side resulting in the reversal of the blood flow. Patient gets syncopal attacks and visual disturbances during exercise of the arm. The blood pressure on the affected side becomes low.

2. *Post constriction dilation of the subclavian artery:* It occurs in the persons having cervical rib. As a result the subclavian artery is raised up on the cervical rib. The artery gets constricted and the post constriction dilatation is formed. The dilated portion of the subclavian artery may become the site of thrombosis and the source for the distal embolism. The process of thrombosis may extend proximally and block the vertebral artery leading to the cerebro-vascular embolic phenomenon.
   As subclavian artery extends upto the lateral border of the first rib it can be compressed and its pulsations can easily be felt as it lies only under the deep fascia.

Right subclavian artery is connected end-to-side to the right pulmonary artery to bypass the pulmonary stenosis of the tetralogy of Fallot. The operation is known as Blalocks operation.

**Abnormal Right Subclavian Artery:** As an abnormality the right subclavian artery may arise from the aortic arch and pass behind the oesophagus. It may compress the oesophagus causing difficulty in swallowing (dysphagia lusoria).

**Aneurysm of the Subclavian Artery:** It commonly involves the third part of the subclavian artery. Due to its intimate relation with the brachial plexus, patient gets pain and complains of weakness and numbness in the arm. Odema of the arm develops when the subclavian vein gets compressed.

**Subclavian Vein (Figure 48):** Subclavian vein does not come in the posterior triangle as it lies behind the clavicle. It begins at the outer border of the first rib as a continuation of axillary vein, runs medially upwards and ends at the medial border of scalenus anterior muscle. It joins the internal jugular vein to form the brachiocephalic vein. It corresponds to the second and third part of the subclavian artery. First part of the subclavian artery has no companion vein.

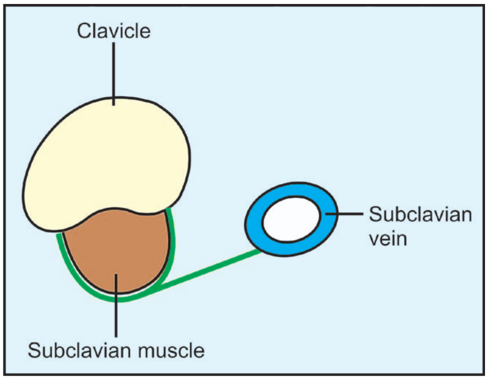



**Figure 48** Showing attachment of the subclavian vein to the fascia covering subclavius muscle and the clavicle

Posterior triangle of the neck is divided into the larger suboccipital triangle above and the smaller subclavian triangle below. The dividing line between the two triangles is formed by the inferior belly of the omohyoid muscle. I personally feel that it is better to study the posterior triangle as a whole first and then the subdivisions.

**Clinical:**

1. Subclavian vein is attached to the back of the subclavius muscle by the facial sheath. Forward movement of the clavicle pulls the vein. During such movement the vein is likely to get torned leading to air embolism, which may prove fatal. *External jugular vein is the first tributary of the subclavian vein and has a valve at the distal end.*
2. *Subclavian vene puncture:* It can be done through the infraclavicular approach. The needle is inserted below the junction of medial and the lateral third of the clavicle. Needle is directed medially upwards behind

the clavicle in the direction of the sternoclavicular joint in order to puncture the subclavian vein. A radio-opaque plastic catheter is pushed inside through the needle into the brachiocephalic vein. The vene puncture is important as one can record the pressure in the right atrium, give blood transfusions and long term intravenous feeding.

**Transverse Cervical Artery (Figure 49):** Transverse cervical artery arises from thyrocervical trunk crosses the scalenus anterior muscle and the phrenic nerve under cover of the sternomastoid. At the anterior border of the levator scapulae it divides into superficial and the deep branches. Superficial branch ramifies on the deep surface of the trapezius. Deep branch goes lower down as the descending scapular artery which is one of the members forming anastomosis around the scapula the other two being the suprascapular and the subscapular arteries. It lies deep to levator scapulae and rhomboidius muscles along the medial border of scapula. It is crossed by the thoracic duct superficially on the left.

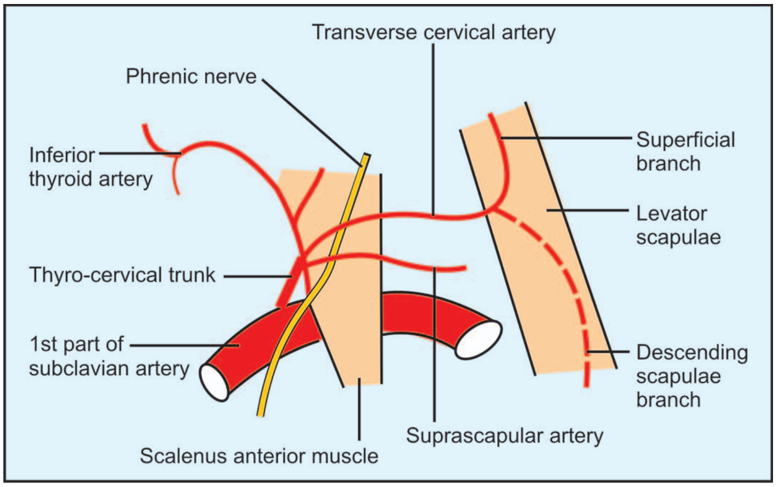



**Figure 49** Showing of branches of transverse cervical artery

**Suprascapular Artery:** Suprascapular artery arises from the thyrocervical trunk, goes laterally and downwards under cover of sternomastoid, crosses the scalenus anterior, phrenic nerve and goes laterally behind the middle third of the clavicle and infront of the subclavian artery. It is crossed by the thoracic duct superficially on the left.

# STERNOMASTOID MUSCLE

**Introduction (Figure 50):** Sternomastoid muscle is an important structure of the neck. It has an oblique course from anteroinferior part of the neck to the posterosuperior part. The structures in the neck such as trachea, oesophagus, common carotid artery, internal jugular vein, vagus nerve, symphathetic chain are crossed superficially by the sternomastoid muscle.

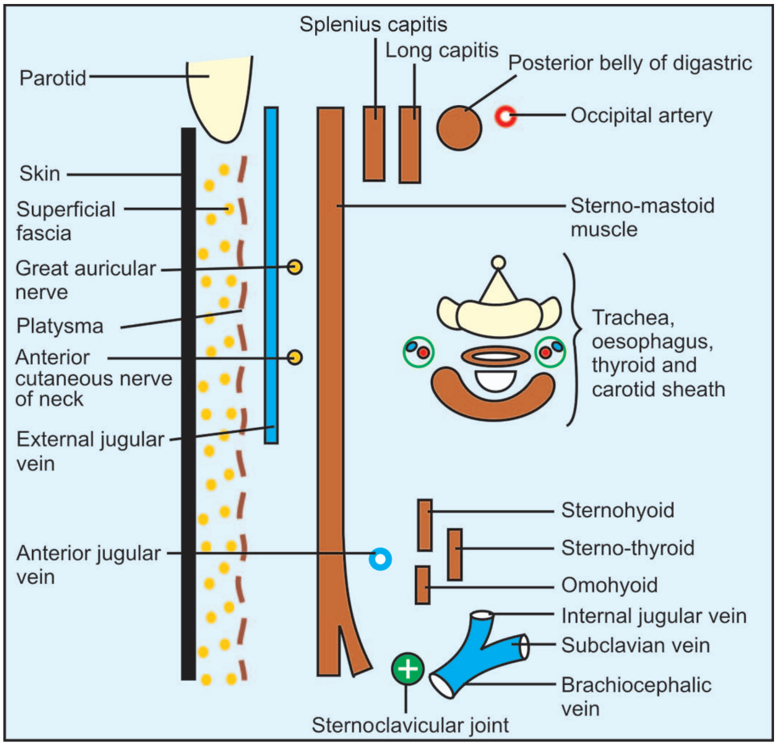



**Figure 50** Showing relations of the sternomastoid muscle (highly schematic)

**Origin:** It has two heads of origin the sternal and the clavicular. The sternal head arises from the manubrium sterni and the clavicular from the medial end of the clavicle. Sternal head of the sternomastoid is tendinus, while the clavicular head is muscular. There is a small depression in between the two heads under which lies the inferior bulb of the internal jugular vein.

**Insertions:** It gets inserted into the base of the mastoid process and the lateral part of the superior nuchal line.

**Nerve Supply:** It is supplied by the 11th cranial nerve (Spinal root of accessory. It also receives nerve supply from the 2nd and the 3rd cervicals (Proprioceptive).

**Blood Supply:** Sternomastoid muscle is supplied by three sternomastoid arteries. Out of which upper two are from the occipital artery and the lower one is from the superior thyroid. These arteries can be described as the upper, middle and the lower. The upper one arises from the occipital artery and runs along the spinal root of the accessory at the apex of the triangle. The middle one arises from the occipital artery at the site, where the hypoglossal hooks the artery. The lower one which is the branch of the superior thyroid artery runs downwards and posteriorly crossing the carotid sheath from the front.

**Relations of the Sternomastoid Muscle (Figure 50):**

1. *Superficial*
   a. Parotid gland
   b. Platysma
   c. External jugular vein
   d. Great auricular nerve
   e. Transverse cutaneous nerve of neck
2. *Deep – At the origin –*
   a. Anterior jugular vein
   b. Sternohyoid and omohyoid muscle
   c. Termination of internal jugular vein
3. *At the insertion*
   a. Splenius capitis
   b. Longus capitis
   c. Posterior belly of digastric
   d. Occipital artery
4. *In the middle:*
   a. Muscles – Scalenus anterior
   b. Scalenus medius
   c. Scalenus posterior
   d. Levator scapulae
   e. Splenius capitis
   f. Inferior belly of omohyoid
5. *Nerves:*
   a. Cervical plexus and its branches
   b. Upper part of brachial plexus
   c. Vagus nerve
   d. Twelfth nerve
   e. Inferior root of ansa cervicalis
   f. Cervical sympathetic chain
6. *Glands:*
   a. Thyroid gland
   b. Lymph nodes
7. *Duct:*
   a. Thoracic duct on left side
8. *Vessels:*
   a. Carotid vessels
   b. Internal jugular vein.

**Action:** When the sternomastoid muscle acts on one side, say right it turns the head to the right approaching the shoulder while the chin and the face are turned to the left. When both the sternomastoid muscles act together they bring the head horizontally forwards such as during feeding. It assists the longus colli in cervical flexion. In supine position they help in raising head from the pillow. When acting from below they raise the thorax in respiration. Sternomastoid muscle may help in the cervical extension. Both sternomastoid muscles are seen acting together when one peeps inside the room from the high window. Both the sternomastoid muscles contract when the chin is pushed up against resistance.

**Clinical:**

1. *Branchial cyst (Figure 51):* Branchial cyst is the remnant of the cervical sinus. The cervical sinus is formed by the caudal growth of the second branchial arch. Normally cervical sinus disappears but may persist in the form of branchial cyst. The cyst is seen along the upper one third of the anterior border of the sternomastoid muscle. The wall of the cyst is lined by squamous epithelium. The diagnosis of the branchial cyst is

almost confirmed when the aspirate from the cyst is examined under the microscope shows cholesterol crystals.

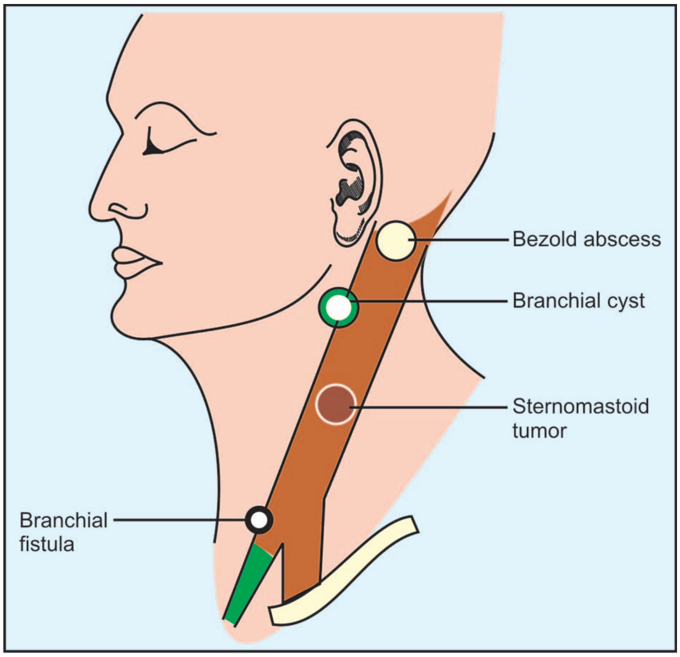



**Figure 51** Showing four common clinical conditions of sternomastoid muscle

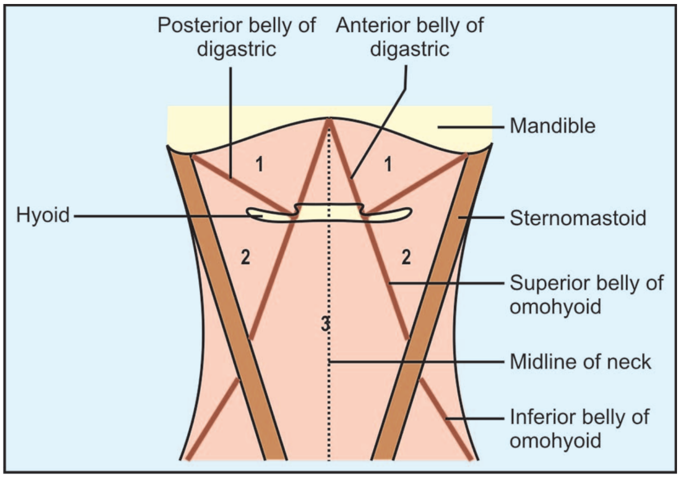
2. *Branchial fistula:* When the branchial cyst breaks, it forms the branchial fistula. It is interesting to remember the fistulus tract passes between the two carotid arteries and reaches the tonsillar fossa. Opening of the branchial fistula is located at the lower one third of the anterior border of the sternomastoid muscle.
3. *Sternomastoid tumor:* During forcep delivery the head is pulled out with the forceps when the shoulders are inside. It causes trauma to the sternomastoid muscle which is followed by haematoma and subsequent fibrosis. The deformity is typical as the head is tilted towards the shoulder of the affected side and the chin and the face is turned to the opposite side.
4. *Wry neck (Torticollis):* It is due to the permanent contracture of the sternomastoid muscle. Spasmodic torticollis is associated with spasm of the sternomastoid muscle which later on involves the trapezius.
5. *Bezold abscess:* Abscess at the tip of the mastoid process occurs following mastoiditis. The pus is pocketed under the deep fascia covering the sternomastoid muscle.

# FRONT OF THE NECK

General idea of the region which lies between two sternomastoid muscles and the base of the mandible is essential before going into the different subdivisions of it.

Between the lower border of the mandible and the upper border of hyoid is the mylohyoid muscle. Over the mylohyoid muscle the anterior and the posterior bellies of the diagastric with their intermediate tendon attached to the hyoid bone by the fascial sling are placed superficial to the mylohoid muscle. Along the posterior belly of diagastric the stylohyoid muscle is associated. Normally stylohyoid muscle is very thin, however it may be as big as the posterior belly of the digastric (Figures 52 and 57).

**Figure 52** Showing anterior triangles of neck: 1. digastric, 2. carotid, 3. intermuscular

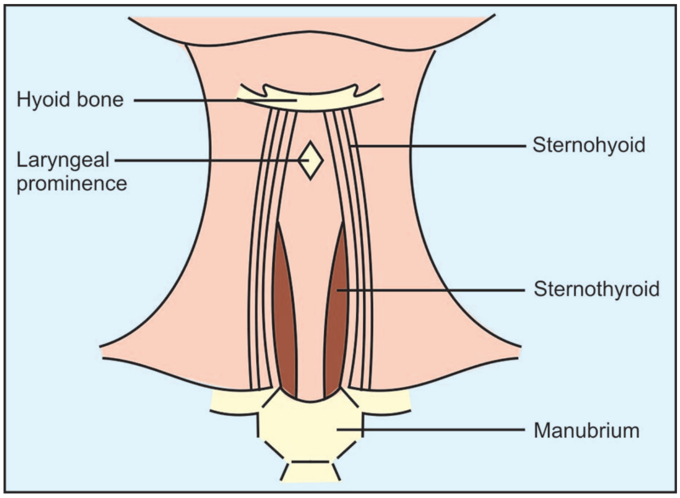



Below the hyoid there are three muscles on either side of the neck arranged in two stratas.

**Deep Strata (Figure 53):**

Muscle running from the sternum to the oblique line of thyroid cartilage is the sternothyroid muscle. Running from the oblique line of the thyroid to the body of the hyoid is the thyrohoid muscle.

**Figure 53** Showing boundaries of intermuscular triangle in the midline of the neck




**Superficial Layer (Figure 54):**

Two muscles lie over the deep layer side by side.

1. Muscle running from sternum to hyoid is placed nearer the midline sternohyoid muscle.

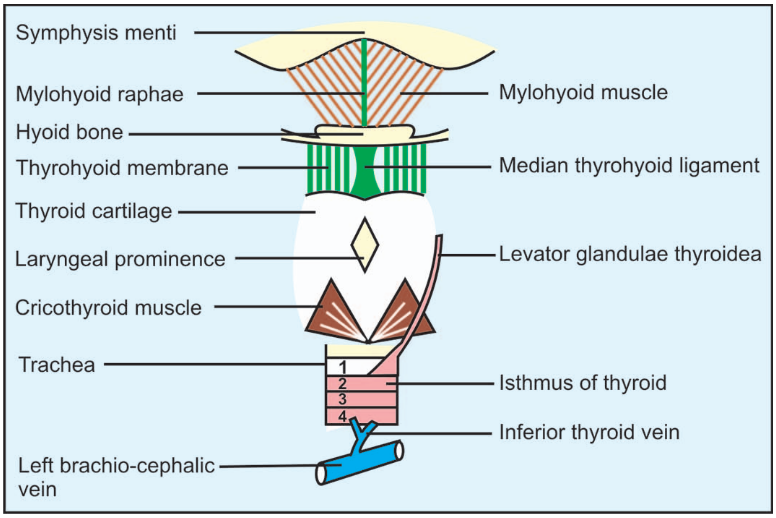



**Figure 54** Showing structures in the midline region of the neck

2. Muscle running from intermediate tendon of omohyoid to the hyoid bone is the superior belly of omohyoid. It is placed lateral to the sternohyoid muscle.

Thyroid gland lies deep to all the muscles making intimate contact with the larynx. Isthmus of thyroid gland lies on the second, third and fourth tracheal rings.

## Geniohyoid Muscle

**Origin (Figure 54A):** Geniohyoid muscle arises from inferior genial tubercle of the mandible.

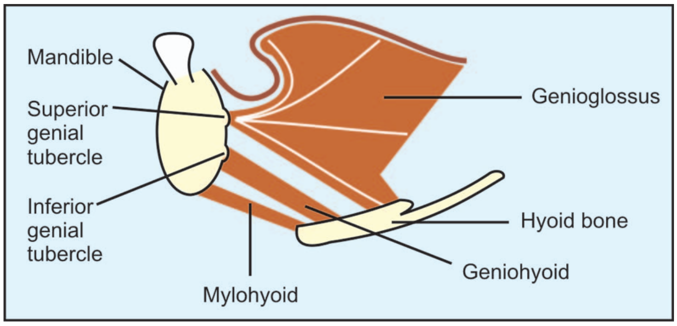



**Figure 54A** Showing origin and insertion of genioglossus, geniohyoid and the mylohyoid muscles

**Insertion:** It gets inserted into the body of the hyoid bone. The geniohyoid muscles of either side lie side by side.

**Nerve Supply:** It is supplied by cervical-1 (C-1) through the hypoglossal nerve.

## Sternohyoid Muscle (Figure 56A)

**Origin (Figures 55 and 56A):** It arises from the back of the manubrium and the sternal end of the clavicle.

**Insertion:** It is inserted into the lower border of the hyoid bone medial to the insertion of the omohyoid muscle.

**Nerve Supply:** It is supplied through ansa cervicalis C1, C2, C3.

# Omohyoid Muscle

**Origin:** The omohyoid muscle has the superior and the inferior bellies. Superior belly arises from the lower border of hyoid bone, lateral to the attachment of the sternohyoid muscle. Inferior belly arises from the suprascapular ligament and the adjoining part of the superior border of the scapula. Both the bellies meet in the form of small intermuscular tendinous structure, under cover of the sternomastoid muscle. Tendinous union of both the bellies lies superficial to the internal jugular vein.

**Nerve Supply:** It is supplied by the ansa cervicalis (Ansa hypoglossi) C1, C2 and C3.

**Thyrohyoid Muscle (Figure 55):** It lies below the sternohyoid and the sternomastoid muscles.

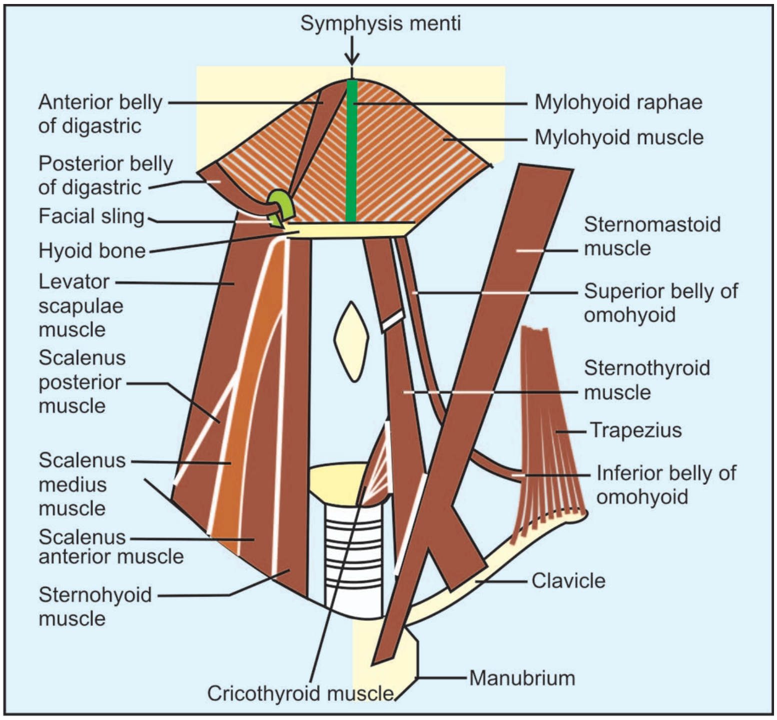



**Figure 55** Showing muscles of front of neck including sternomastoid and trapezius muscle

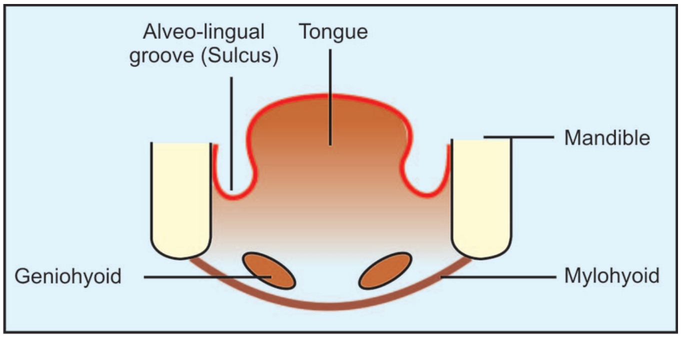


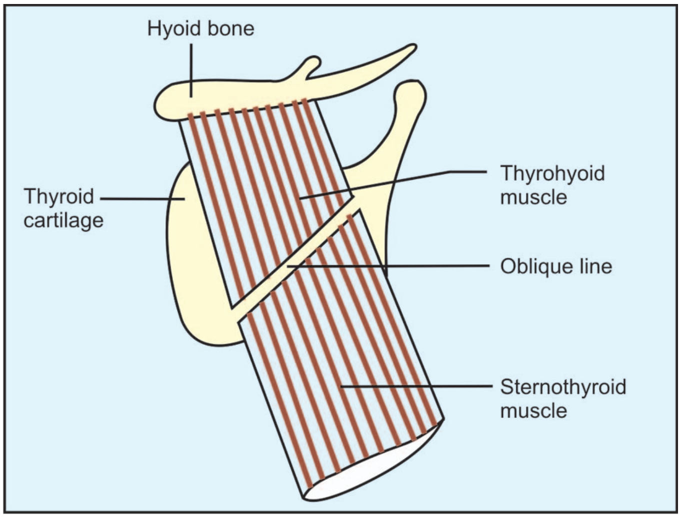

**Figure 55A** Showing transverse section through tongue and the mandible

**Origin:** It takes origin from the oblique line of the thyroid cartilage where the sternothyroid muscles gets inserted.

**Insertion (Figure 56):** It is inserted into the hyoid bone.

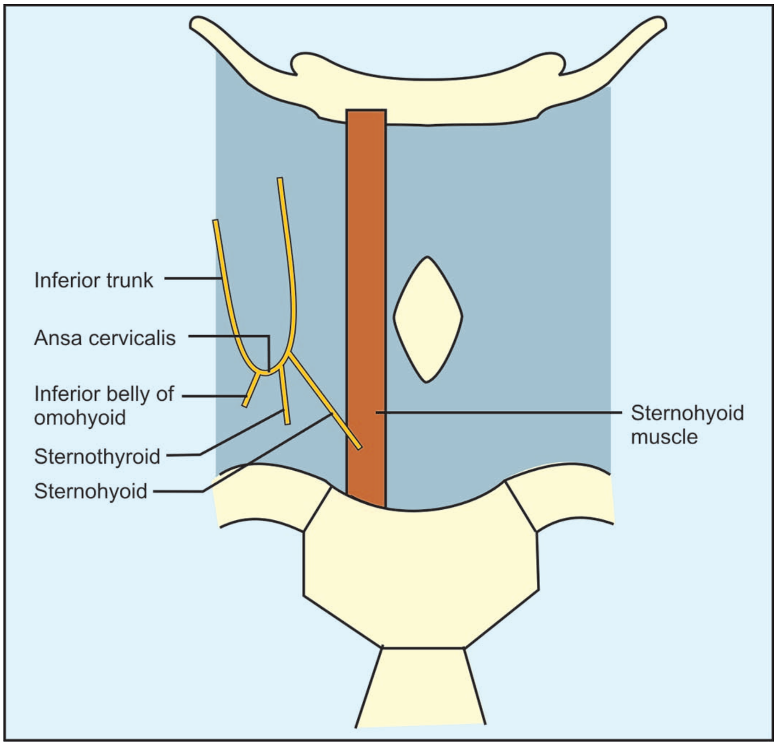
## Sternothyroid Muscle (Figures 56 A and B)

**Figure 56A** Showing sternothyroid and thyrohyoid muscles




**Nerve Supply:** C1 through hyoglossal nerve.

**Figure 56B** Showing ansa cervicalis and sternohyoid muscle




**Origin:** It arises from the posterior surface of the manubrium, lower than the origin of sternohyoid muscle. (Please remember hyoid for higher)

**Insertion:** It gets inserted into the oblique line of the thyroid cartilage.

Oblique line of thyroid cartilage gives attachments to three muscles.

1. Origin of inferior constrictor muscle of pharynx.
2. Insertion of sternothyroid and
3. The origin of thyrohoid muscle.

**Action of the Infrahyoid Muscles:** In general the infrahyoid muscles are depressors of the hyoid bone.

## Mylohyoid Muscle (Figures 53 and 55)

**Introduction:** The mylohyoid muscle forms the floor of the mouth and is also known as the oral diaphragm, similar to the respiratory and the pelvic.

**Origin (Figure 55A):** It arises from the mylohyoid line on the inner surface of the body of the mandible. Anterior ¾ fibres interdigitate with each other in the midline between the symphysis menti and the hyoid bone to form the mylohyoid raphae. The posterior fibres, get inserted into the hyoid bone.

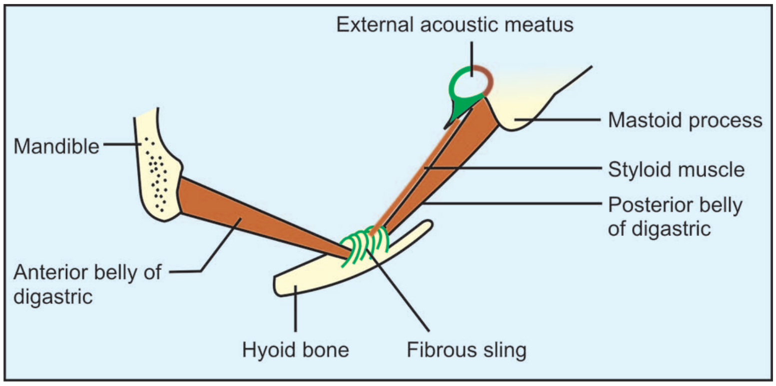
**Nerve Supply:** Mylohoid muscle is supplied by the nerve to mylohoid a branch of the inferior dental nerve. It must be remembered that the nerve to the mylohoid pierces the sphenomandibular ligament and runs in the mylohyoid groove along with mylohyoid vessels. It passes further between the anterior belly of digastric and mylohyoid muscles. Both of the muscles are supplied by the mylohyoid nerve. Submental artery, the branch of the facial artery runs forwards pierces the mylohyoid muscle and supplies the sublingual salivary gland and the floor of the mouth.

**Action:** It forms important component of the floor of the mouth and supports the weight of the tongue. During its contraction, tongue is lifted up along with the hyoid.

**Digastric Muscle:** Digastric muscle has two bellies the anterior and the posterior, which meet through a common tendinous sling which is attached to the hyoid bone.

**Origin of Anterior Belly of the Digastric (Figure 57):** Anterior belly of the digastric muscle arises from the digastric fossa of the mandible.

Figure 57 Showing digastric and muscles and stylohyoid




**Origin of Posterior Belly of the Digastric:** Posterior belly of the digastric arises from the mastoid notch of the temporal bone.

**Nerve Supply:** Anterior belly of the digastric is supplied by the nerve to mylohyoid, the branch of the inferior dental which is the branch of the mandibular. Mandibular nerve is the nerve of the first branchial arch. The posterior belly of digastric is supplied by the facial nerve. Facial nerve is the nerve of the second branchial arch.

**Comment:** The meeting of the anterior and the posterior bellies of the digastric can be described as the shake – hand between the first and the second branchial arches.

**Stylohyoid Muscle (Figure 57):** It takes orign from the posterior surface of the styloid process, nearer its base and gets inserted into the body of the hyoid bone near the junction of the greater cornu.

**Nerve Supply:** It is supplied by the seventh (Facial nerve) near the stylomastoid foramen, through which the facial nerves leaves the cranium.

# ANTERIOR TRIANGLES OF THE NECK

For the descriptive purpose the region is divided into the following triangals (see Figure 52).

1. Muscular triangle
2. Carotid triangle
3. Digastric triangle
4. Submental triangle

**Muscular Triangle:** Anterior limit is formed by midline of neck extending from the hyoid bone to the sternum.

**Superolateral Boundary:** Superior belly of omohyoid.

**Inferolateral Boundary:** Lower part of the anterior border of the sternomastoid muscle.

# CAROTID TRIANGLE

It is considered as the key triangle of the neck. It is known as the carotid triangle as the common carotid, internal carotid, external carotid arteries, the carotid body and the carotid sinus are the contents of the triangle. The triangle has the site where common carotid divides into the internal and the external carotid arteries. External carotid artery gives five of its branches. The arterial pulsations at this point are forceful and can be felt with the finger (Carotid point) (Figure 58).

**Figure 58** Showing carotid triangle with other triangle of the neck

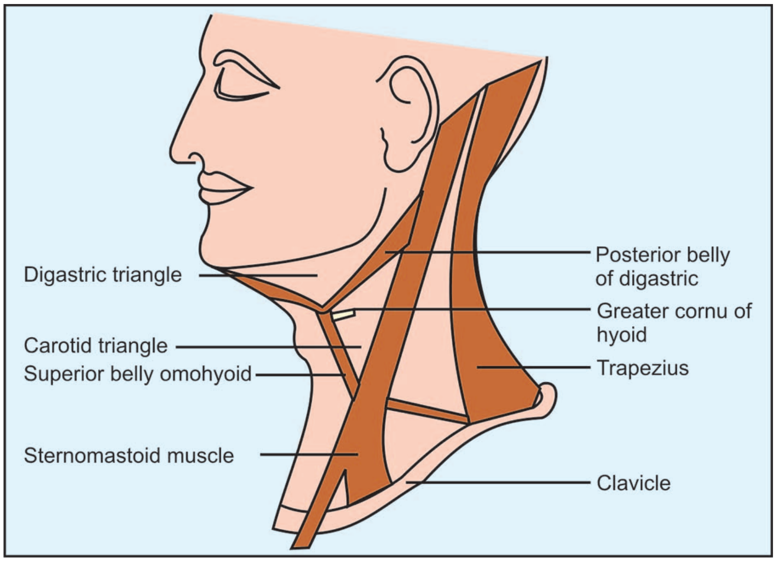
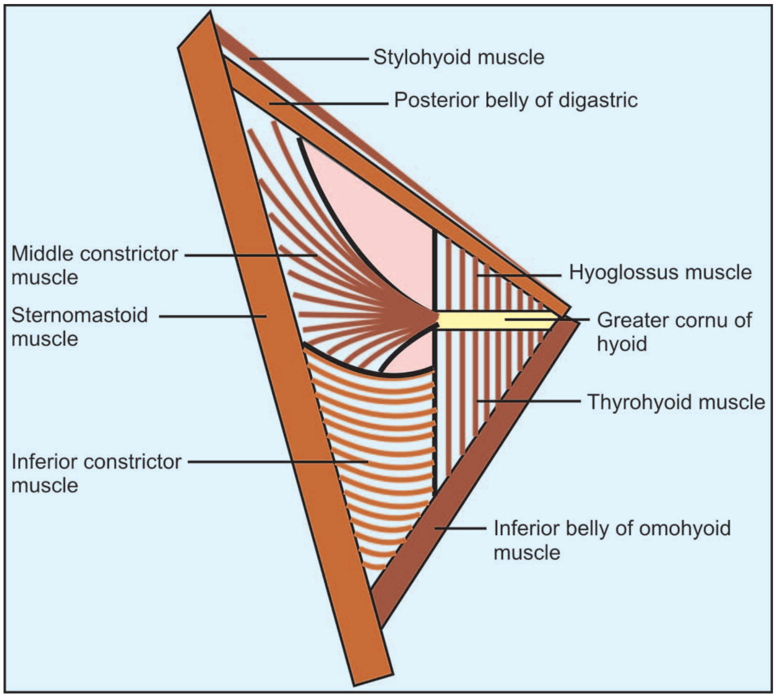



**Figure 58A** Showing muscles forming floor of carotid triangle




It is bounded by the anterior border of the sternomastoid, superior belly of the omohyoid and the posterior belly of digastric, supplemented by the stylohyoid muscle.

**Posterior Boundary:** Is formed by the anterior border of the sternomastoid muscle.

**Superior Boundary:** Is formed by the posterior belly of the digastric muscle and the stylohoid muscle.

**Inferior Boundry:** Superior belly of omohyoid muscle.

**Roof:** Is formed by skin, superficial facia, platysma and the deep facia.

**Floor (Figure 59):** Floor is formed by four muscles:

1. Hyoglossus,
2. Thyrohyoid,
3. Inferior constrictor, and
4. The middle constrictor muscles

**Figure 59** Showing carotid triangle and contents. Please note that hypoglossal nerve crosses three arteries in the triangle

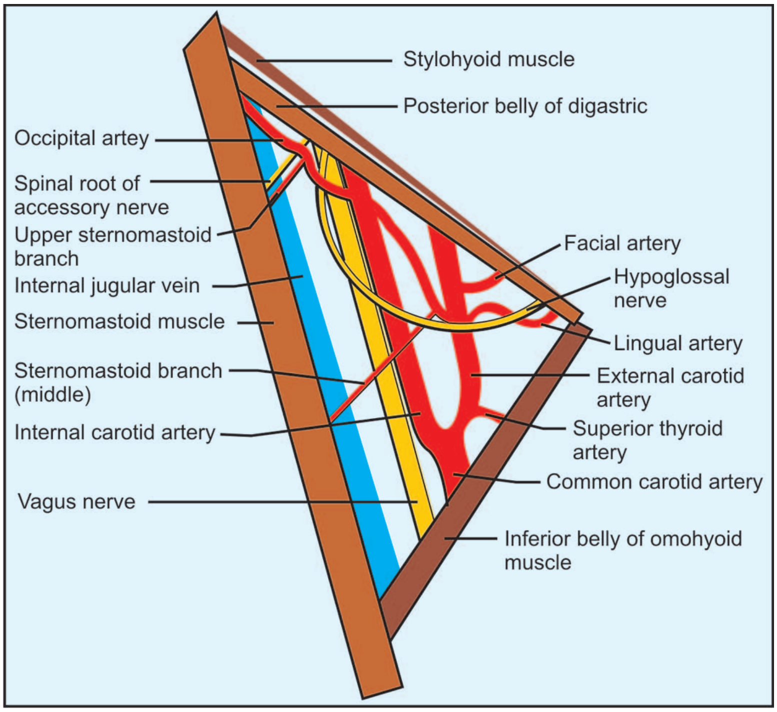
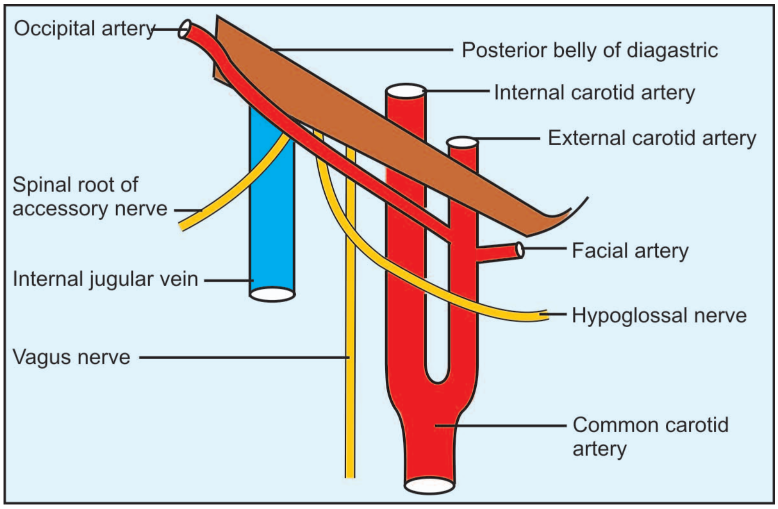



**Figure 59A** Showing structures under posterior belly of digastric muscle




**Contents:** Under the anterior border of the sternomastoid muscle lies the internal jugular vein. Spinal root of the accessory nerve is seen at the postero-superior angle of the triangle crossing the internal jugular vein superficially. Winding around the lateral aspect of the internal jugular vein are the second and third cervical nerves. They form the inferior limb of the ansa cervicalis. Common carotid artery lies in front of the internal

jugular vein. It divides into two terminal branches the external and internal carotid arteries at the upper border of the thyroid cartilage. External carotid artery lies in front of the internal carotid, however, in the upper part of the triangle the internal carotid artery lies deeper and goes medial to the external carotid artery.

At the lower border of the posterior belly of the digastric, the external carotid artery gives, the occipital and facial branches. Occipital artery arises from the posterior aspect of the external carotid and runs posteriorly upwards below the posterior belly of the digastric muscle.

Facial artery after origin from the anterior aspect of the external carotid artery, runs upwards under the posterior belly of digastric. Below the origin of the facial artery, the lingual artery arises from the external carotid. It runs forwards, upwards and loops around the greater cornu of the hyoid bone. Thereafter it passes under the posterior belly of diagastric and the stylohyoid muscles. The loop formed by the lingual artery is crossed by the hypoglossal nerve. Hypoglossal nerve after entering the triangle under the posterior belly of digastric and stylohyoid lies between the internal jugular vein and the internal carotid artery posterior to the vagus. It crosses the internal, external carotid arteries and the loop of the lingual.

The hypoglossal nerve crosses three arteries successively and successfully one after the other in the carotid triangle which can be described as the Hat-tric by the hypoglossal nerve. It hooks around the lower sternomastoid branch of the occipital artery and goes further to cross the carotids.

Hypoglossal nerve gives the descending hypoglossi which joins the descendens cervicalis to form the ansa cervicalis (Hypoglossi) in front of the carotid sheath. After crossing the loop of the lingual artery hypoglossal nerve supplies the geniohyoid and the thyrohyoid muscles. Superior thyroid artery arises from the anterior aspect of the external carotid artery and runs downwards and forwards under cover of the superior belly of the omohyoid, to the thyroid gland. It gives infrahyoid, superior laryngeal and the sternomastoid branches. Ascending pharyngeal artery arises from the external carotid artery and lies at the deeper level in the triangle.

Ascending pharyngeal artery is the first branch of the external carotid artery, slender in structure but undertakes the long journey to the base of the skull. During its vertical course it lies between the pharynx medially and the internal carotid artery laterally. It gives three meningeal branches which enter the foramen lacerum, the jugular foramen and the hypoglossal canal antero-posteriroly (LJH).

Anterior facial vein crosses the posterior belly of the digastric superficially and unites with the anterior division of the retro-mandibular vein to form the common facial vein which drains into the internal jugular vein. Carotid sinus and carotid body are at the common carotid bifurcation.

**Carotid Body:** Carotid body is situated at the bifurcation of the common carotid artery in the carotid triangle. It has chemoreceptor cells which are sensitive to pH and temperature of blood. Tumour of the carotid body is known as chemoductoma (Potato tumour). It presents as a lump at the carotid bifurcation which moves across but does not move along the common carotid artery.

**Investigation:** Arteriography

**Treatment :** Excision of the tumor with bypass (silicon bypass tube).

**Complication of the Operation:** Torrential haemorrhage and death.

**Carotid Sinus:** It contains pressure receptors and respond to the rise and the fall of blood pressure.

**Digastric Triangle (Figure 60):** Digastric triangle is situated below the lower border of the body of mandible. It is also known as the submandibular region.

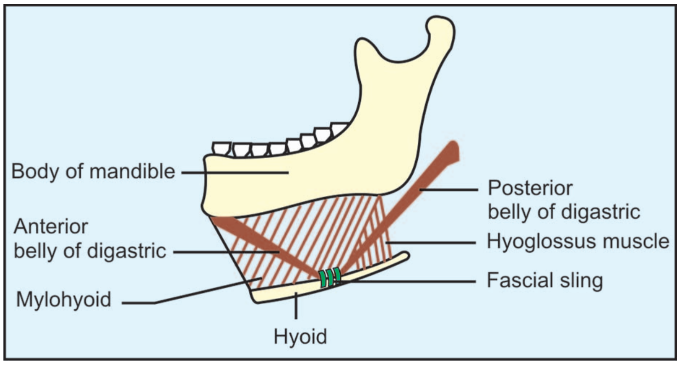



**Figure 60** Showing boundaries and muscles of floor of digastric triangle

**Boundaries:** The upper boundary is formed by the lower border of the mandible, anterior-inferior boundry by the anterior belly of the digastric and the postero-inferior by the posterior belly of the digastric and the stylohyoid muscles.

**Floor:** Floor is formed by mylohyoid muscle anteriorly and the hyoglossus posteriorly. Floor is divided into two parts by the stylomandibular ligament.

**Roof:** Roof is formed by the skin, superficial fascia, platysma, cutaneous nerves, and the veins; which are described along with other structures. Small lymph nodes lie on the surface of the submandibular salivary gland. They drain the tongue, the teeth, the lip and the cheek.

Arrangement of structure posterior to the stylomandibular ligament:

They are as under from the superficial to deep. (Figure 61)

1. Parotid gland
2. External carotid artery
3. Styloglossus muscle
4. Stylopharyngeus muscle
5. Glossopharyngeal nerve
6. Internal carotid artery
7. Internal jugular vein and
8. The vagus nerve.

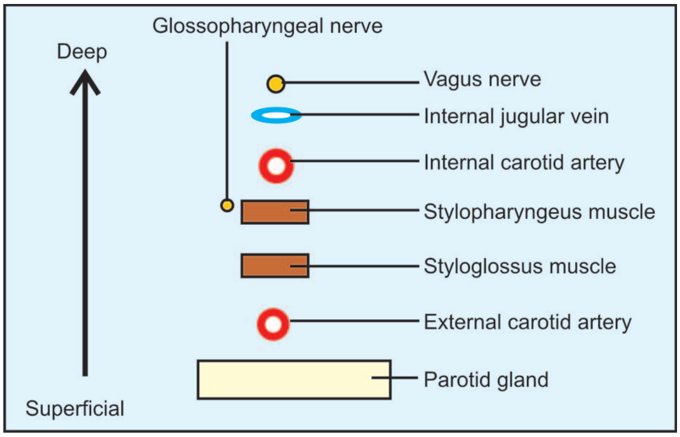



**Figure 61** Showing relations of structures posterior to stylomandibular ligament from superficial to deep

Structures in front of the stylomandibular ligament:

They are arranged as under from the superficial to deep.

1. Common facial vein.
2. Submandibular salivary gland.
3. Facial artery – it appears at the antero-inferior angle of the masseter muscle.

## Submandibular Salivary Gland

Submandibular salivary gland is an important content of the digastric triangle.

**Classification:** It is the mixed type of salivary gland having mucous and serus cells.

*Size:* It is of a size of walnut.

*Weight:* 25 to 30 grams.

*Capsule:* It is formed by the investing layer of the deep cervical fascia.

**Parts (Figures 62 and 63):** It has two parts:

1. The superficial to the mylohyoid, and
2. The deep to the mylohyoid.

Superficial part is larger and is continuous with the deep part of the gland around the posterior border of the mylohyoid muscle.

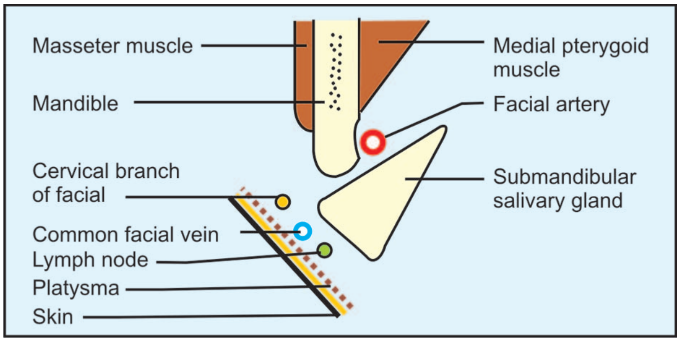



**Figure 62** Showing relations of lateral and inferior surfaces of submandibular salivary gland

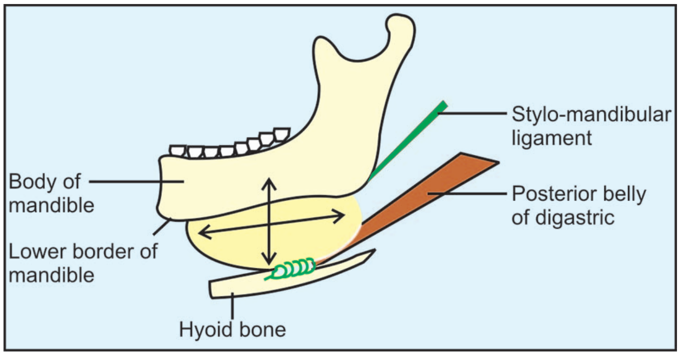
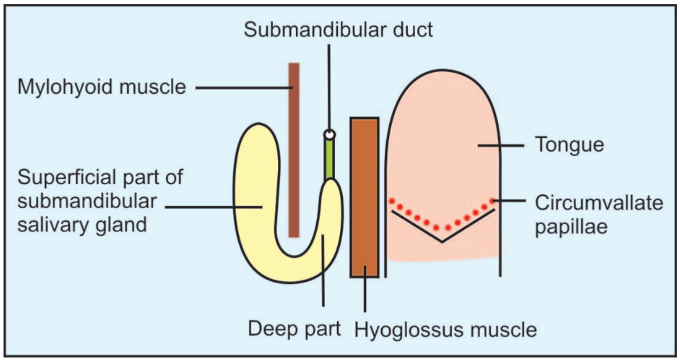



**Figure 63** Showing extent of submandibular salivary gland

**Superficial Part (Figure 64):** Anteriorly it overlaps the anterior belly of digastric and posteriorly it extends upto stylomandibular ligament. The stylomandibular ligament lies between the parotid gland and the submandibular salivary glands. The ligament is the condensation of the investing layer of fascia of the neck between the tip of the stylohyoid process and the angle of the mandible. Superiorly the gland goes under the body of the mandible. Inferiorly it overlaps the common tendon of the digastric muscle.

*Surfaces of the submandibular gland:*

1. Supero-lateral
2. Inferiolateral and
3. The medial




**Figue 64** Showing superficial and deep parts of submandibular salivary gland

**Relations of the Inferio-lateral Surface:** The skin, superficial fascia, platysma, common facial vein cervical branch of facial nerve and the lymph nodes.

**Relations of the Supero-lateral Surface:** Submandibular fossa of the mandible, medial pterygoid muscle and the facial artery. Facial artery first lies deep to the gland, between the gland and the medial pterygoid muscle next it reaches the anterioinferior angle of the masseter muscle by piercing the deep fascia to enter the face.

**Relations of the Medial Surface (Figure 65):** It is the largest surface. It is divided into three parts, the anterior, middle and the posterior. Anterior part is related to the mylohyoid muscle, mylohyoid nerve and the vessel. (All mylohyoid). Middle part is related to the hyoglossus muscle and the structures on it.

The structures over the hyoglossus are the lingual nerve, submandibular salivary ganglion, hypoglossal nerve and the accompanying veins. Posterior one-third of the medial surface is related to the stylohyoid ligament which runs from above downwards separating the submandibular gland from the parotid gland, glosopharyngeal nerve, styloglossus muscle and facial artery. Below it overlaps the posterior belly of digastric and stylohyoid muscles.

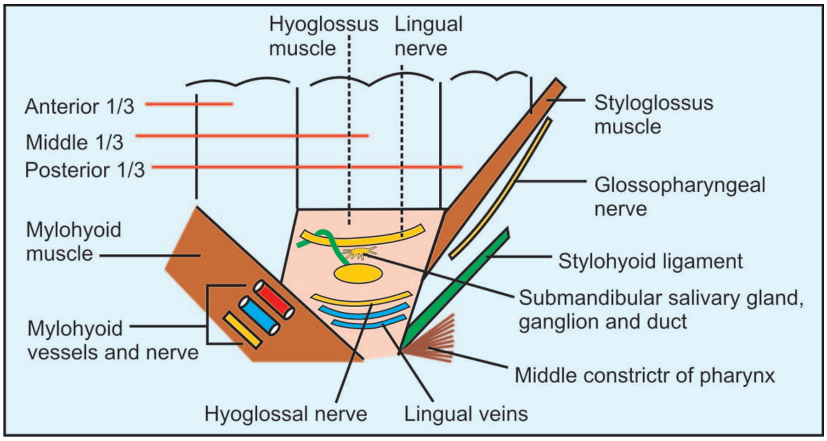



**Figure 65** Showing relations of medial surface of the submandibular salivary gland

**Deep Part of the Gland (Figure 66):** It lies on the hyoglossus muscle under cover of the mylohyoid. It is situated between the lingual nerve above and the hyoglossal nerve below.

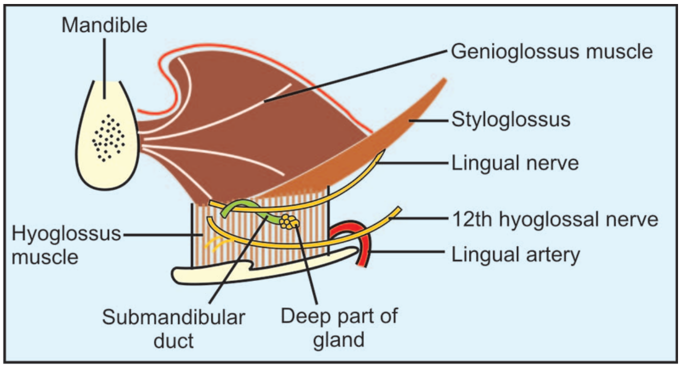



**Figure 66** Showing structures on hyoglossus muscle

**Relations of the Posterior Pole:** Two glands namely the parotid and the thyroid and two nerves namely the hypoglossal and the facial are the relations of the posterior end of the gland.

**Duct of the Submandibular Salivary Gland:** Duct of the submandibular salivary gland is 5 cm in length. It arises at the middle of the deep part of the gland and runs between the mylohyoid and hyoglossus muscles to open on the sublingual papilla in the floor of the mouth, which is situated on either side of frenulum linguae.

**Fascial Sheath of the Gland:** As the investing layer of deep fascia of neck meets the lower pole of the gland, it splits into superficial and deep layers. Superficial layer after covering the inferior surface of the gland gets attached to the lower border of the mandible, while the deep layer goes upwards, covers the medial surface and ends at the mylohyoid line.

**Blood Supply:** The submandibular salivary gland is supplied by the branches of the facial and the lingual arteries.

**Nerve Supply (Figure 67):** It is from the superior salavary nucleus in the pons. The fibers run along the facial nerve, leaves it in the vertical part of the facial canal as the chordatymphani nerve which joins the lingual nerve at an acute angle. The fibres accompanying the lingual nerve join the submandibular salivary ganglion get relayed and supply secretomotor fibres to the submandibular salivary gland.

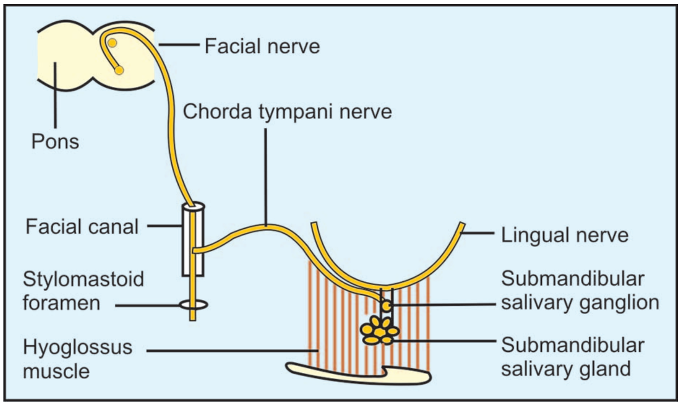



**Figure 67** Showing parasympathetic supply of submandibular salivary gland

**Histology (Figure 68):** Submandibular gland is a mixed type of salivary gland. It is of the compound-tubulo-alveolar variety. Connective tissue forms the capsule from which number of fibrous septae enter the gland from all the sides. Glandular tissue consists of alveoli. There is a well defined basement membrane with serous and mucous cells. Group of alveoli make lobules and lobules form the lobe. The serous cresecents (cresents of Giannuzzi or demules of Hiadenhan) are seen at the peripheri of the alveoli.

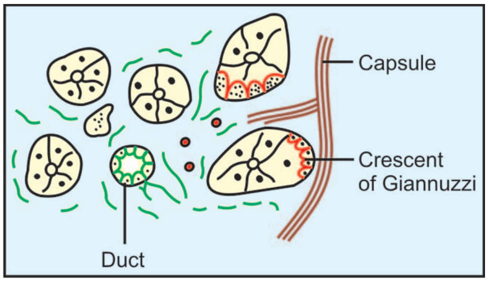



**Figure 68** Histological appearance of submandibular salivary gland

**Development:** It is endodermal in origin. It develops from alveolingular groove in the form of number of buds which canalised.

**Submental Triangle:** Submental triangle is situated below the symphysis menti, its base is formed by the hyoid bone, sides by the anterior bellies of the digastric muscles and the apex lies at the symphysis menti. Its floor is formed by the mylohyoid muscle.

**Contents:**
1. Submental lymph nodes. They drain the tip of the tongue and the lower lip.
2. The anterior jugular vein begins in the triangle.

**Sublingual Salivary Gland (Figure 69):** They are the smallest of the salivary glands situated under the oral mucosa and lies in the sublingual fossa of the mandible near the symphysis menti.

*Shape :* Almond

*Weight:* 3 to 4 grams

*Relations:* Figure 69

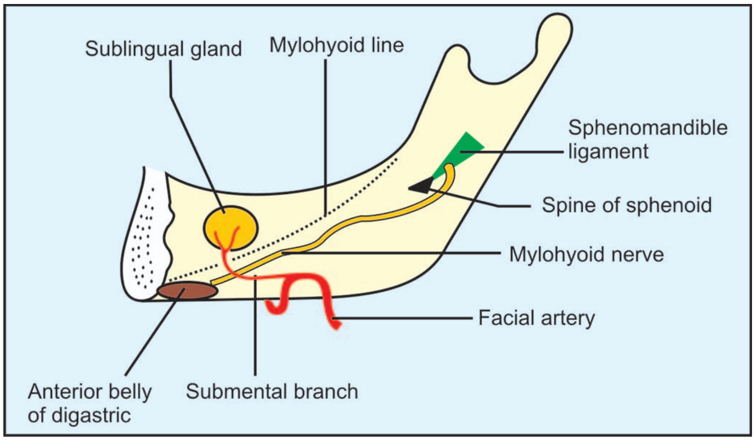



**Figure 69** Showing origin of mylohyoid and its relations with the course of submental artery

**Above:** It is related to the mucosa of the oral cavity which is raised as the sub-lingual fold.

**Below:** Mylohyoid muscle.

Laterally mandible above the mylohyoid line, medially genio-glossus muscle.

Sublingual salivary gland has 8-20 ducts which open separately on the sublingual fold in the floor of mouth.

**Blood Supply:** It is supplied by the sublingual branch of the lingual and the submental arteries.

**Nerve Supply:** Parasympathetic secretomotor fibers from the chorda tympani through the lingual nerve. At times the separate sub-lingual ganglion may be present.

**Clinical Sialography:** A suitable radio opaque material is injected into the duct system of the parotid or the submandibular salivary glands and the X-ray is taken. It gives information about the obstruction of the duct, dilatation, fistula or tumor.

**Salivary Calculus:** The secretion of the submandibular salivary gland being thick and the drainage non-dependent, the incidence of salivary calculi is more in the submandibular salivary gland. The secretion of the parotid gland is thin being of the serous variety the incidence of the salivary calculi is less than the submandibular salivary gland.

# SCALENUS ANTERIOR MUSCLE

Scalenus anterior muscle is the key muscle of the root of the neck.

**Origin:** It arises from the anterior tubercles of the third, fourth, fifth and the sixth cervical vertebrae. (All typical cervical vertebrae).

**Insertion:** The muscle runs vertically downwards gets narrowed to form the flat tendon which is inserted into the scalene tubercle on the medial border of the first rib and the bony ridge in front of the groove for the sub-clavian artery.

*Relations :*

**Superficial Relations (Figures 70 to 73):**

1. Sternomastoid.
2. Phrenic nerve
3. Inferior belly of omohyoid.
4. Transverse cervical artery.
5. Suprascapular artery.
6. Anterior Jugular vein.
7. Subclavian vein.
8. Ascending cervical artery
9. Prevertebral fascia.
10. Clavicle and subclavius muscle.
11. Thoracic duct crosses the medial border of the muscle only on left side.

**Posterior Relations:**

1. Second part of subclavian artery
2. Lower trunk of brachial plexus
3. Scalenus medius muscle.
4. Lungs and pleura.
5. Suprapleural membrane.
6. Costocervical trunk.

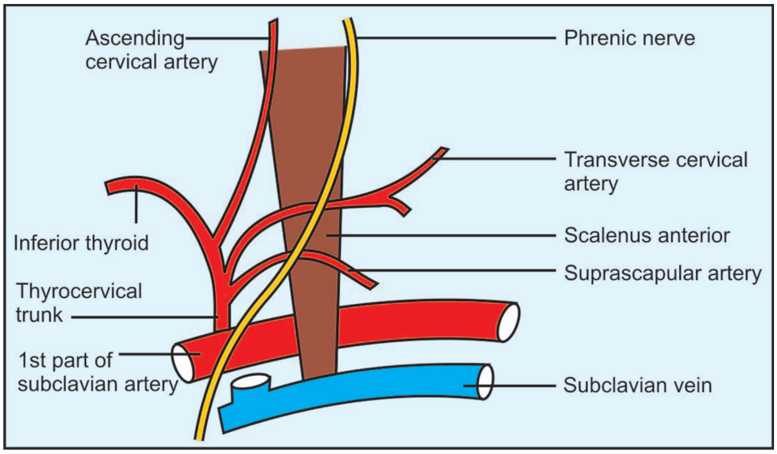



**Figure 70** Showing anterior relations scalenus anterior muscle of the left. Please Note that thoracic duct is omitted for clarity

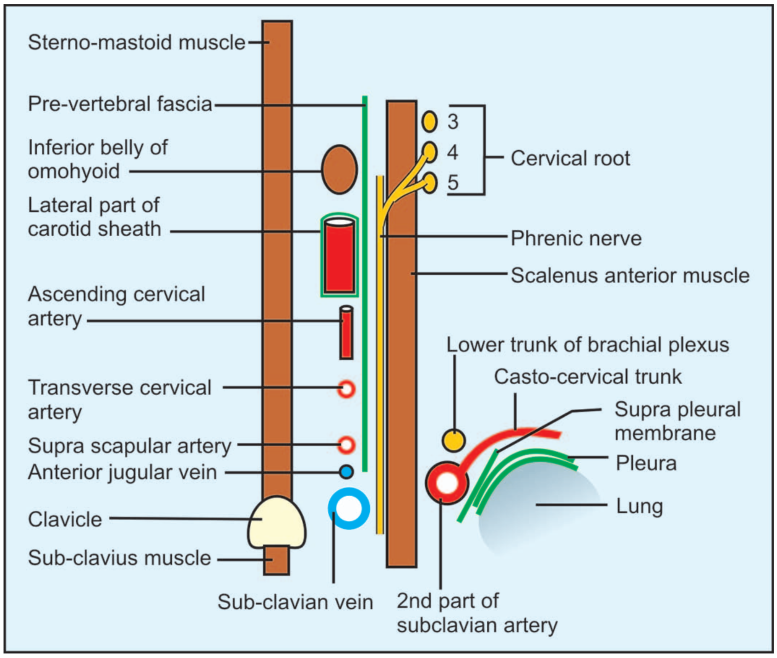



**Figure 70A** Showing relations of scalenus anterior muscle in sagittal section (diagrammatic)

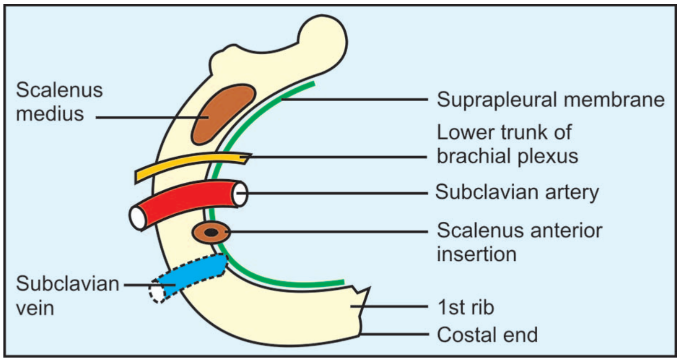



**Figure 71** Showing posterior relations of scalenus anterior muscle

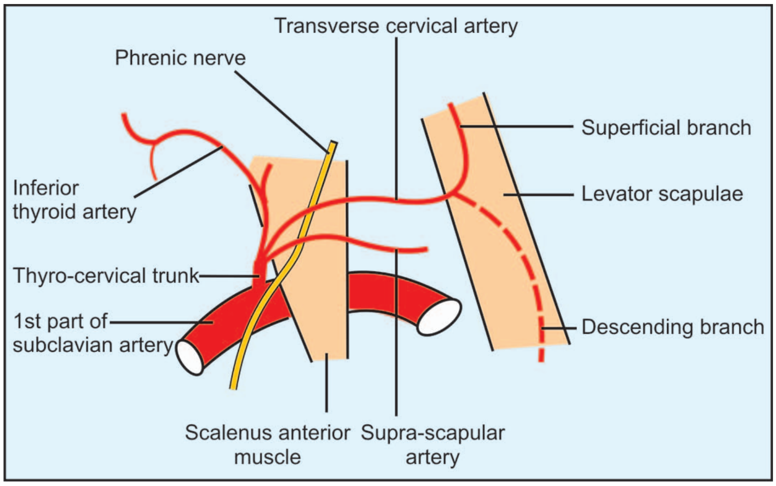



**Figure 72** Showing thyrocervical trunk and its branches (Diagramatic)

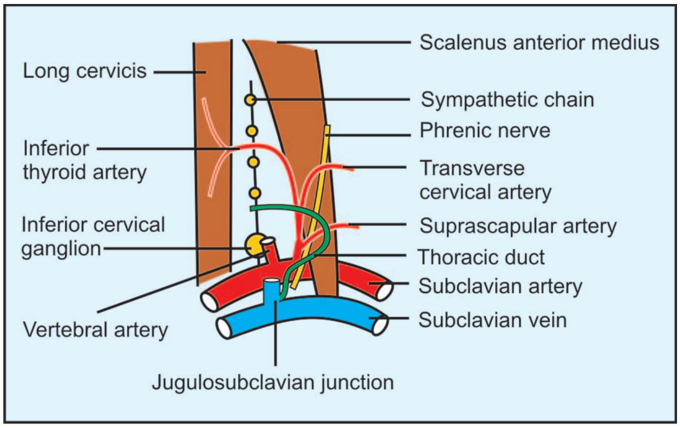



**Figure 73** Showing triangular interval medial to the scalenus muscle

Cervical plexus lies along the lateral border of scalenus anterior muscle. Carotid sheath lies over the medial border of this muscle to some extent (Figure 73A).

**Action:** It bends the cervical vertebral column forwards and laterally and rotates it towards the opposite side. When it acts from above it elevates the first rib.

**Nerve Supply:** From branches of ventral rami of fourth, fifth and sixth cervical nerves.

# MEDIAN REGION OF THE FRONT OF THE NECK

It includes one inch wide region in the midline of the neck, extending between the chin and the sternum. For descriptive purposes it is considered separately as suprahyoid and the infrahyoid regions. The region at the level of the hyoid is treated as a separate zone.

**Suprahyoid region:** It consists of mylohyoid muscle with its central raphae, anterior jugular veins and the submental lymph nodes.

**At the level of the hyoid –** Hyoid bone, hyoid bursa and thyrohyoid membrane.

**Infrahyoid region: (Figures 74 and 75)** Infrahyoid region is bounded by three muscles on either side arranged in two layers. Here it must be remembered that below the hyoid bone the intermuscular region is bounded on either side by the sternohyoid muscle in the upper part and the sternothyroid muscle in the lower (Figure 53).

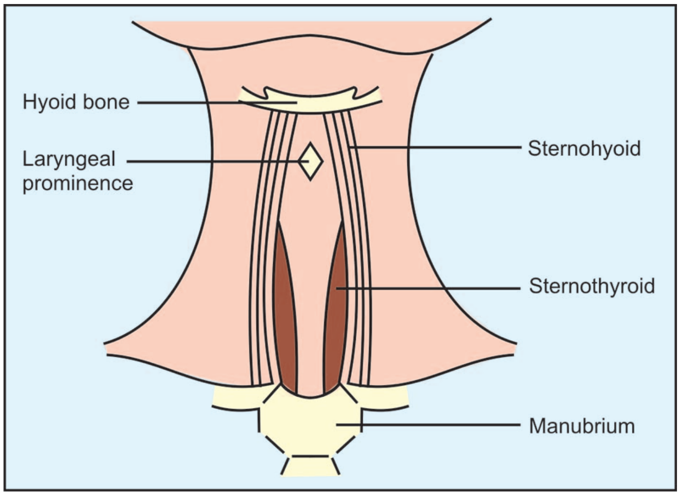



**Figure 74** Showing boundaries of intermuscular triangle in the midline of the neck

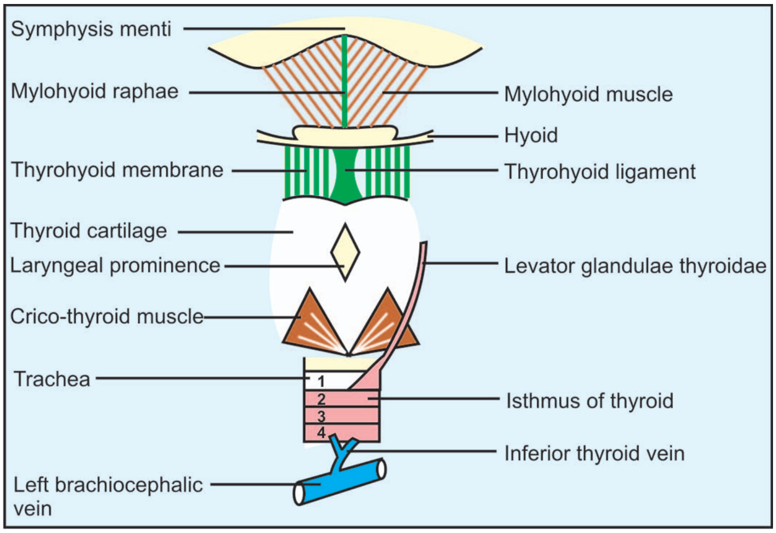



**Figure 75** Showing structures in the midline region of the neck

Number of structures are seen in the infrahyoid region in the mid-line of the neck. They are as follows.

1. Thyrohyoid membrane
2. Laryngeal prominence.

3. Cricothyroid ligament.
4. Cricothyroid muscles.
5. Cricothyroid ateries.
6. Isthmus of the thyroid gland.
7. Pyramidal lobe of thyroid gland when present.
8. Levator glandulae thyroidae.
9. Inferior thyroid veins.
10. Anterior jugular veins and the anterior jugular arch.
11. Sternal head of the sternomastoid muscle and a lymph node.
12. Left brachiocephalic vein- when situated higher.

Bony prominence felt below the mastoid process is of the transverse process of the atlas. Fourth cervical vertebra is at the level of the upper border of the thyroid cartilage, while the sixth cervical vertebral level is at the cricoid cartilage, where the pharynx ends and the oesophagus beings. (Draw 'C' and make 6.) C for 6 (Cricoid 6).

**Anterior Jugular Vein:** Anterior jugular vein begins below the chin and descends downwards by the side of the mid-line of the neck. Two fingers above the sternum it turns laterally deep to the sternomastoid muscle infront of the scalenus anterior muscle to end in the external jugular vein. Above the sternum it is connected with the fellow of the opposite side by means of an anterior jugular arch. Anterior jugular arch lies in the suprasternal space of Burns. Anterior jugular vein is devoid of valves.

# SCALP AND TEMPLE

**Scalp:** Scalp is the name given to the soft structure covering the skull. Its anterior limit is the eye brows and the posterior the superior nuchal line. Its lateral limits being the superior temporal lines.

It is made-up of five layers:

S - Skin
C - Connective tissue (Superficial fascia containing vessels and nerves).
A - Aponeurosis of the occipito-frontalis muscle.
L - Loose areolar tissue.
P - Pericranium (Periosteum of skull bones).

Scalp has its source of blood supply, from the periphery, therefore, base of the flap should be at the periphery, to keep the blood supply of the flap intact (Inverted hockey shaped incision protects peripheral vessels from damage).

**Skin:** It is studded with hair follicles and firmly fixed to the superficial fascia due to hair roots.

**Superficial Fascia: (Figure 76):** Superficial fascia is tough and fixed to the skin on one hand and the aponeurosis on the other. It has rich blood and the nerve supply.

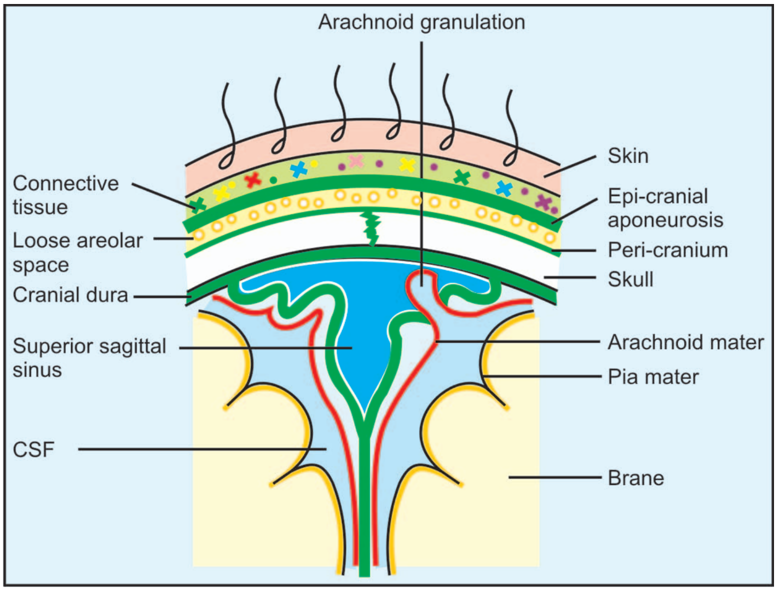



**Figure 76** Showing layers of scalp. Please note that the superior sagittal sinus

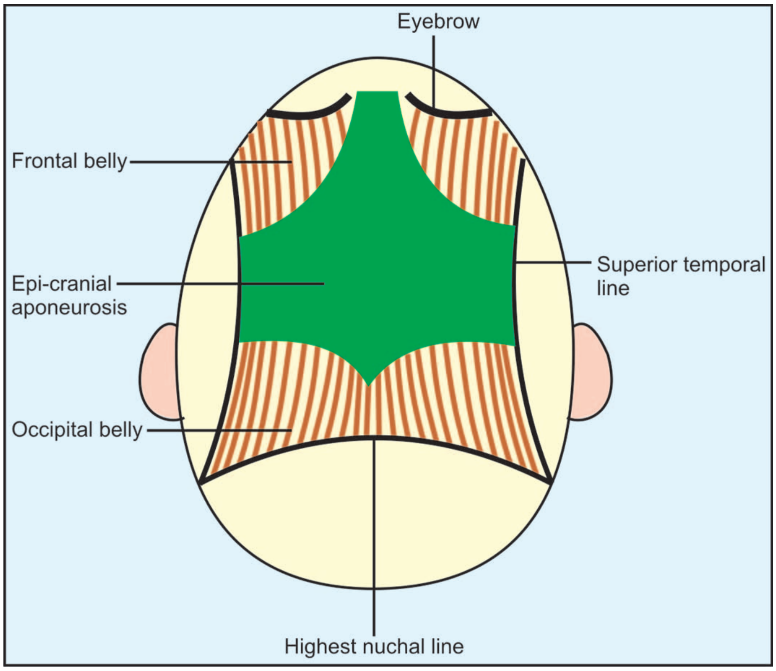
**Aponeurotic Layer:** Aponeurotic layer is thin and tough, it covers the vault of the skull. Anteriorly it meets the frontal and posteriorly the occipital bellies.

**Frontal Belly:** Frontal belly has no bony attachment. It runs anteriorly from the aponeurotic layer and inter-mingled with the orbicularis oculi muscle and gets inserted into the skin of the lower part of forehead in the region of the eye-brows. It sends an extension in the mid-line towards the nose. It is known as the procerus muscle.

**Corrugator Supercilii:** It is situated at the medial end of the eye-brow under the orbicularis occuli. It arises from the medial end of the superciliary arch and runs laterally mixing the muscles there. It exerts traction on the skin above the mid point of the orbit. It produces vertical lines on the supra-nasal part of forehead. It protects the eye from the bright sunlight. It is involved in frowning.

**Occipital Belly (Figure 77):** Occipital belly of occipito-frontalis muscle is attached to the superior nuchal line. In between the two bellies is the aponeurosis which extends posteriorly.

Figure 77 Showing muscles of the scalp (occipito-frontalis) with epi-cranial aponeurosis




Lateral attachment of the aponeurosis is to the superior temporal lines. Skin, superficial fascia and the aponeurosis move as one single layer over the pericranium due to loose areolar tissue.

**Action of the Frontal Belly:** Frontal belly corrugates the skin of the forehead while the procerus wrinkles the skin of the nose.

**Nerve Supply of the Occipital Belly:** Occipital belly is supplied by the posterior auricular branch of the facial nerve.

**Nerve Supply of the Frontal Belly:** It is supplied by the temporal branch of the facial nerve.

**Clinical:** The loose areolar space between the aponeurosis and the pericranium is important as it is the potential dangerous space. Collection of blood, pus or the crebro-spinal fluid do not descend beyond the superior temporal and the superior nuchal lines. However, the frontal belly of occipital frontalis has no bony attachment in the face. It is attached to skin of the eye brows. Hence, the blood collected descends in the upper lid. The extension of blood in the upper lid gives a typical appearance to the eye and is known as black eye or Panda's eye.

**Nerve Supply of the Scalp can be Grouped as Under (Figure 78):**

1. Anterior to the ear: one motor and four sensory.
2. Posterior to the ear: one motor and four sensory.

**Nerve Anterior to the Ear:**

1. **Motor:** Temporal branch of facial
2. **Sensory:**
   a. Supratrochlear branch of ophthalmic division of trigeminal.
   b. Supra-orbital branch of ophthalmic division of trigeminal.
   c. Zygomaticotemporal branch of maxillary division of trigeminal.
   d. Auriculotemporal branch of mandibular division of trigeminal.

**Nerve Posterior to the Ear:**

1. Motor: Posterior auricular branch of facial.
2. Sensory:

a. Posterior division of great auricular nerve (C2, C3)
b. Lesser occipital nerve from cervical plexus
c. Greater occipital nerve C2
d. Third occipital nerve C3.

**Figure 78** Showing nerve supply of scalp

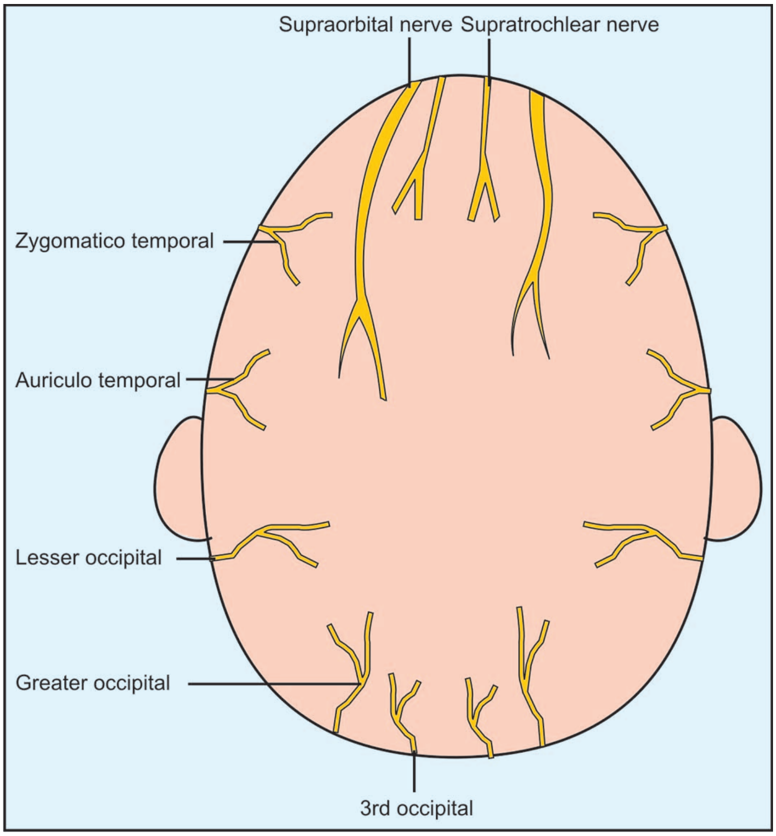
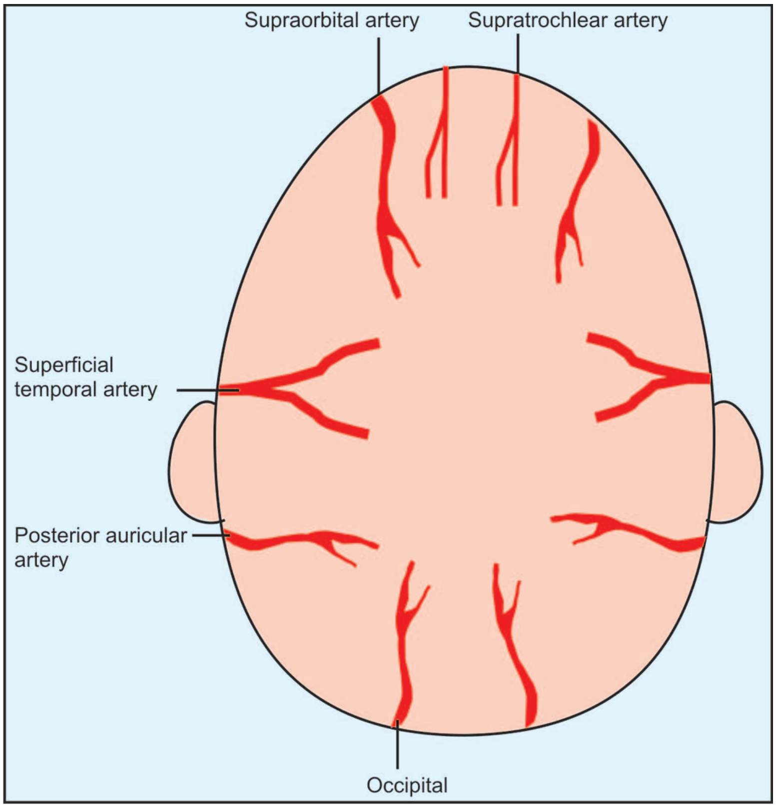



**Figure 79** Showing blood supply of scalp



**Auriculo-temporal Nerve (Figures 80A and B):** Auriculo-temporal nerve arises from the posterior division of the mandibular nerve in the infratemporal fossa. It has two roots which surround the middle meningeal artery. The nerve supplies the parotid gland with the secretomotor fibres from the inferior salivary nucleus. Auricular part of this nerve supplies the skin of the tragus and the upper part of the pinna, outer surface of the tympanic membrane and the skin of the external auditory meatus. Temporal division of the nerve innervates the skin of the temple. It is to be remembered that it does not supply the parotid fascia, which is supplied by the great auricular nerve.

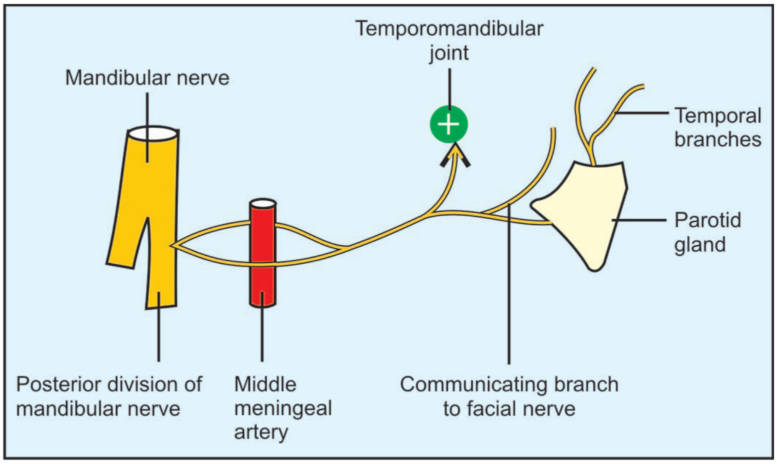



**Figure 80A** Showing course of auriculo-temporal nerve

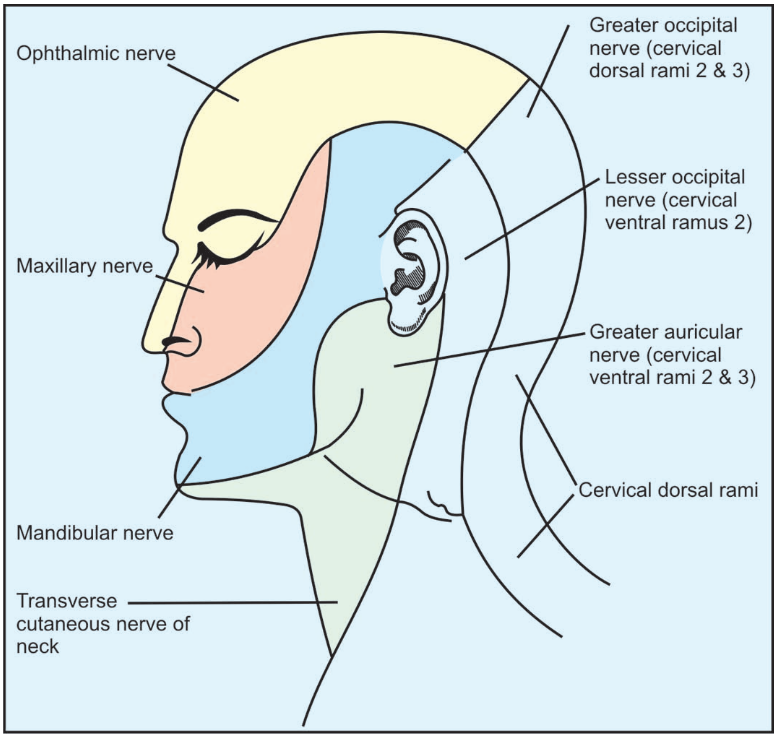



**Figure 80B** Showing distribution of cutaneous nerve supply of head and face

Temporal branch of the facial nerve supplies the anterior and the superior auricular muscles, frontal belly of occipitofrontalis and the upper part of the orbicularis oculli.

Posterior auricular nerve, the branch of the facial arises from the nerve soon after its exit from the stylomastoid foramen. It supplies the occipital belly of occipitofrontalis and the superior and the posterior auricular muscles.

Great auricular nerve (C2, C3) supplies the lower and the posterior part of the face, lower part of the auricle and the area behind it. It has already been mentioned that this nerve innervates the parotid fascia.

Lesser occipital nerve (C2) supplies the upper part of the cranial surface of the auricle and some area of the lateral part of the back of the neck (Figure 81).

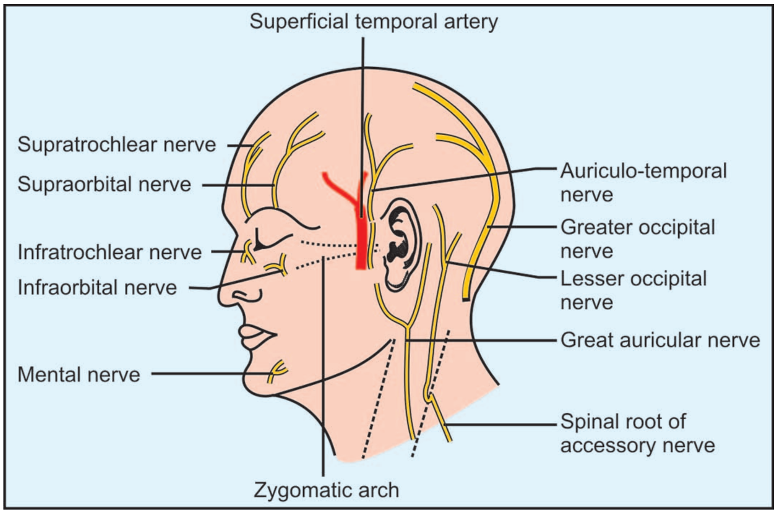



**Figure 81** Showing cutaneous nerve of face and neck. Please note that the superficial temporal artery and the auriculo temporal nerve cross the zygomatic arch superficially. The artery infront and the nerve behind

**Greater Occipital Nerve (2)**

Greater occipital is the largest cutaneous nerve in the body. It is the branch of the posterior primary ramus of the second cervical nerve. It supplies most of the area of the skin at the back of the head.

**Third Occipital Nerve:**

It is a cutaneous branch of the posterior primary ramus of the third cervical nerve. It supplies the skin over the external occipital protuberance and the skin over the upper part of the neck.

**Arteries of Scalp and Face (Figures 80 and 82):**

Scalp has the rich blood supply by the arteries running to it from the periphery. There are five arteries out of which three lie in front of the auricle and two behind.

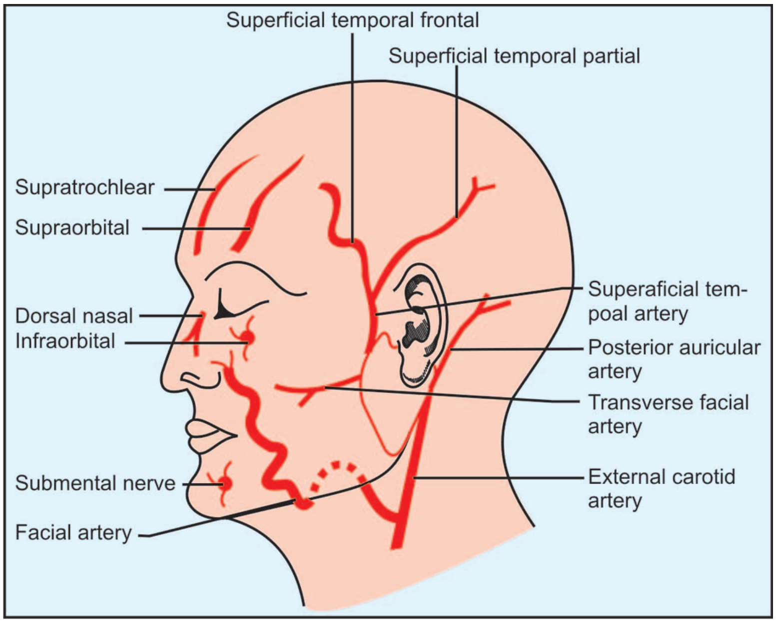
1. Supraorbital and
2. Supratrochlear are the branches of the ophthalmic artery.
3. Superficial temporal is one of the two terminal branches of the external carotid artery. The superficial temporal artery appears in the temporal region just in front of the auriculo-temporal nerve at the superior surface of the parotid gland. It divides into anterior and posterior branches an inch above the zygomatic arch. It is the anterior branch which is clearly seen taking a wavy course while going towards the frontal eminence in elderly people. It gives following branches.

1. *Transverse facial:* Arise just below the zygomatic arch.
2. *Middle temporal:* Arises from superficial temporal and crosses the root of zygoma, pierces the temporal fascia and produces a well marked groove on the bone above the external auditory meatus.
3. *Zygomatic branch:* Runs along the upper border of the zygomatic arch in between the two layers of temporal fascia.

*Posterior auricular artery:* Posterior auricular artery arises from the external carotid artery under the parotid gland behind the auricle. It follows the upper border of the posterior belly of the digastric and further accompanies the posterior auricular nerve.

*Occipital artery:* It is a branch of the external carotid artery given in the carotid triangle. It pierces the trapezius muscle lateral to the greater occipital nerve at the superior nuchal line.

**Figure 82** Showing arteries of the face side view

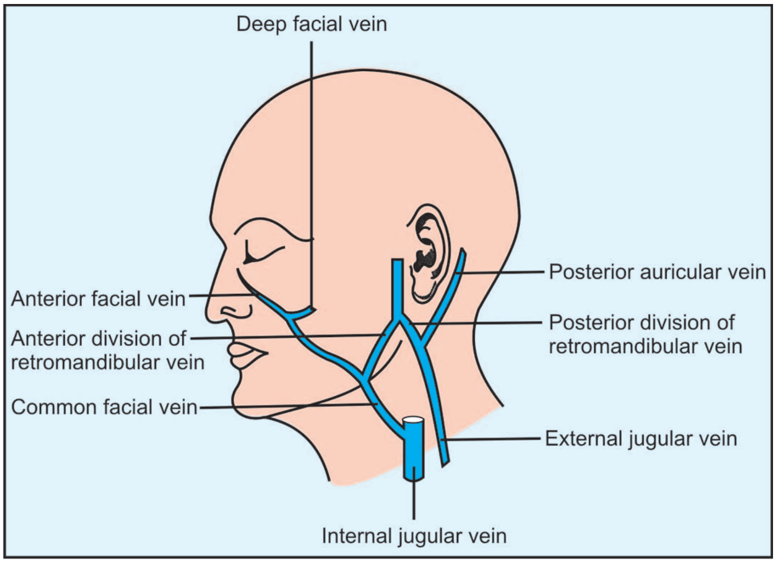



## Veins of the Face (Figure 83):

They form free anastomosis which lie in the superficial fascia of the scalp and the temple.

1. Supratrochlear
2. Supraorbital
3. Superficial temporal.
4. Middle temporal
5. Posterior facial: It divides into anterior and posterior divisions.
6. Occipital veins.

**Figure 83** Showing veins of the face and neck




It is important to remember that the occipital veins are connected with the venous sinuses inside the cranium by means of the emissary veins. These may provide the accessory channels for spread of infection.

Supraorbital and supratrochlear veins join freely with the orbital veins and unite at the medial angle of the eye to form the angular vein the further course of which is known as the anterior facial vein (Figure 83).

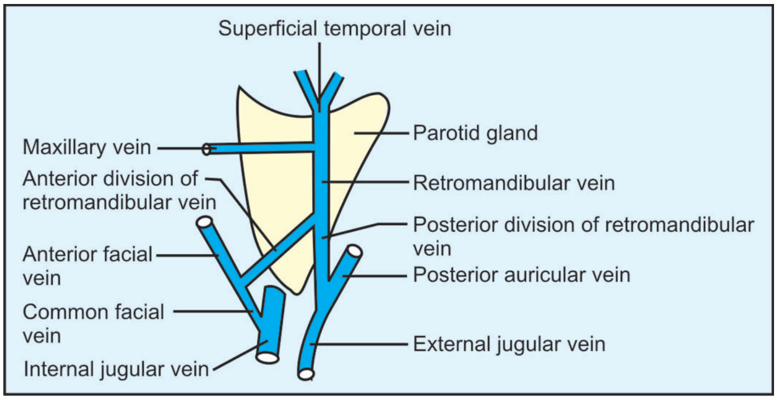



**Figure 84** Showing formation of external jugular and common facial veins

Superficial temporal vein is formed in the temporal region. The supratrochlear, supraorbital, posterior oricular and the occipital veins drain into it. The superficial temporal vein is formed above by union of the anterior and the posterior roots. Above the zygoma it is joined by the middle temporal vein after which it crosses the posterior part of the root of the zygoma and enters the parotid glands. It is joined by the maxillary vein to form the retro-mandibular vein. Retromandibular vein divides into the anterior and the posterior divisions. Anterior division unites with the anterior facial vein to form the common facial vein which opens into the internal jugular vein. Posterior division of the retro-mandibular vein unite with the posterior auricular vein and forms the external jugular vein at the lower pole of the parotid gland.

**Danger Area of Face:** Anterior facial vein has no valves (Figures 83 and 84). It is connected to the cavernus sinus through the inferior ophthalmic vein and the pterygoid venous plexus. The anterior facial vein joins the pterygoid venous plexus through the deep facial vein. The pterygoid venous plexus is connected to the cavernous sinus. Infection from the upper lip and the alae of the nose may reach the cavernous sinus and cause thrombosis of the cavernuous sinus which is a serious complication.

**Sub-occipital Veins:** Majority of the occipital veins leave the company of the occipital artery by passing across the lateral border of the semispinalis capitis muscle. This sub-occipital plexus thus formed lies under the above said muscle (Figure 85).

**Lymphatic Drainage of the Scalp and Temple (Figure 86):** It can be grouped into two.

1. *Anterior to ear* – Drain into lymph nodes on the superficial surface of the parotid gland.
2. *Posterior to ear* – Drain into mastoid and occipital group of nodes.

Pericranium is loosely attached to the bones except at the sutures where its attachment is firm. Collection of blood or pus under the pericranium takes a shape of the underlying bone. On the other hand, collection of fluid under the epicranial aponeurosis is extensive.

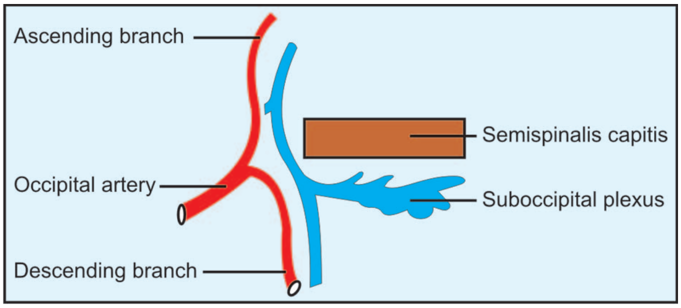



**Figure 85** Showing suboccipital plexus of vein

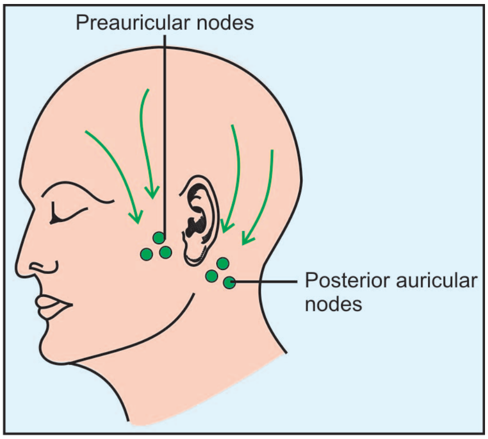



**Figure 86** Showing lymphatic drainage of scalp and temple

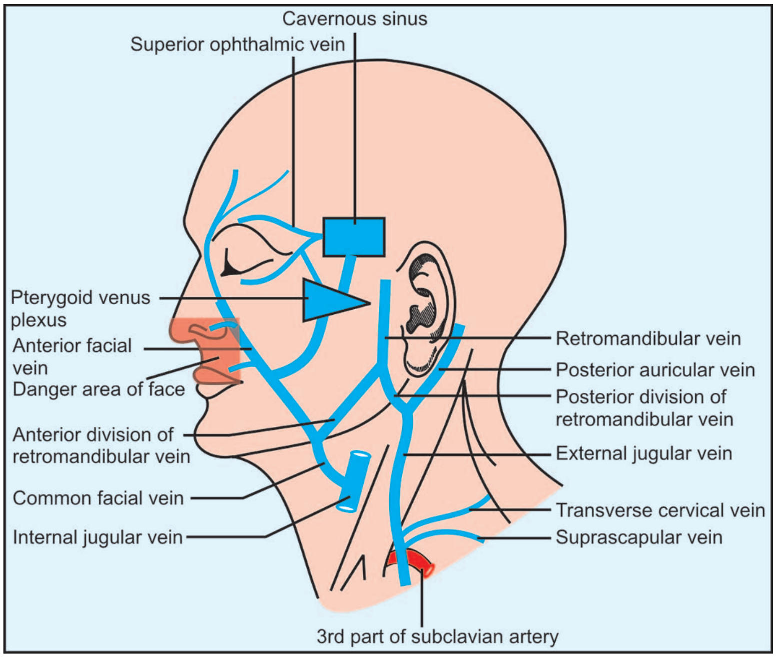



**Figure 87** Showing veins of the head and the neck including danger area face side view

**Peculiarities of the Scalp:**

1. Skin and superficial fascia and aponeurosis move over the pericranium freely as the single layer. This is possible because of the subaponeurotic space which is extensive and filled with loose areolar tissue.
2. Nerve supply of the scalp is rich, therefore, infections of the scalp are more painful.
3. Blood supply of the scalp is rich, therefore, bleeding is profuse. The reason for the profuse bleeding is due to the fact that the fibrous tissue surrounding the vessels do not allow them to collapse. Healing of the wound of scalp is early due to rich blood supply.
4. There are plenty of sebaceous glands, hence, scalp is the commonest site for the sebaceous cysts. Large and long standing sebaceous cysts erode the pericranium and may destroy skull cap. Before removing a sebaceous cyst of an old standing X-ray of the skull is mandatory.
5. Subaponeurotic space is important because of the following facts:

a. Pus, blood or cerebrospinal fluid can collect in the subaponeurotic space. This delays the compression of brain to some extent (*Safety-valve mechanism*).

b. It is the danger zone of the scalp as infection of the scalp can enter the cranium through the emissary veins leading to intracranial venous sinus thrombosis.

6. Vascular tumors may establish communication with intracranial dural venous sinuses.
7. Injury to the scalp made even by a hard and blunt object looks like an incised wound due to underlying firm aponeurosis.
8. Wounds do not gape when the epicranial aponeurosis is not a part of the wound.
9. Due to the presence of dens subcutaneous tissue. Inflammatory swellings of the scalp are smaller in size.

# MUSCLES OF THE FACE

These are the muscles of facial expressions, and arise from the bones of the face and get inserted into the skin of the face. They are not covered with the deep fascia. All the muscles of face, are supplied by the facial nerve. First let us consider the orbicularis oculi. It has three parts (Figures 88 and 89):

1. Orbital part
2. Palpebral part
3. Lacrimal part.

**Figure 88** Showing frontalis with attachments of muscles of face. Note the course of facial artery in the face

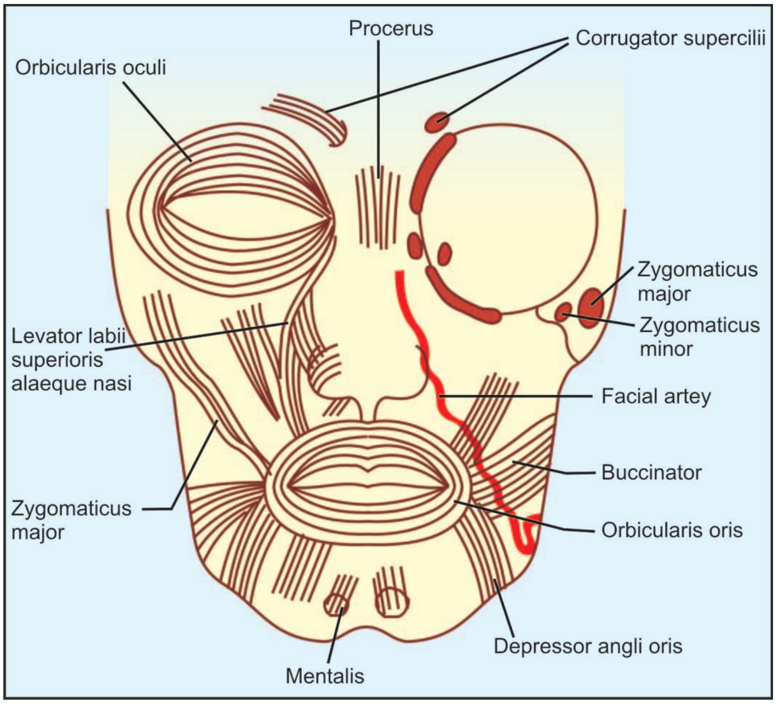
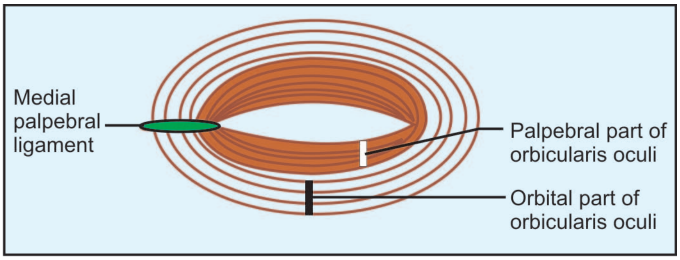



**Figure 89** Showing parts of orbicularis oculi




**Orbital part:** Orbital part arises from medial palpebral ligament and the adjoining bone runs around the orbital margin and returns back to the point of its origin. It is to be noted that it has no bony attachment laterally.

**Palpebral part:** Palpebral part arises from the medial palpebral ligament and the adjoining bone arrangement of the fibres is similar to that of the orbital part. They too have no bony attachment laterally. Some fibres form a small bundle at the margin of the lid. It is known as ciliary bundle. Due to irritation there can be sudden and trouble-some spasm of the palpebral part. It is known as blepharospasm.

**Lacrimal Part (Figure 90):** It arises from the posterior margin of the lacrimal fossa and the fascial sheath of the sac.

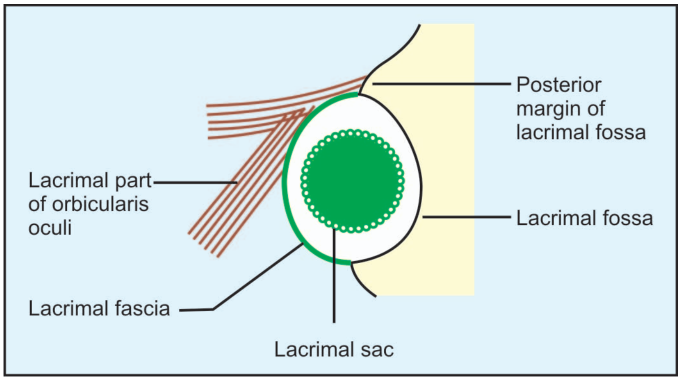



**Figure 90** Showing attachment of lacrimal part of orbicularis oculi (horizontal section)

**Muscles of Face:**
- Procerus
- Levator labii superioris alaeque nasi.
- Compressor naris, dilator naris.
- Depressor septi nasi.

**Muscles of Lips and Cheek:** They are arranged into two layers, superficial and deep.

**Orbicularis Oris:** This is the sphincter muscle of the mouth.

**Levator Labii Superioris Alaeque Nasi:** It arises from the frontal process of maxilla. It divides into two slips, one going to lip while the next going to the ala of the nose.

**Levator Labii Superioris:**
Origin - from infraorbital margin
Insertion - Upper lip

## Zygomaticus Minor and Major

**Zygomaticus Minor:** *Origin:* From zygomatic bone medial to the origin of zygomatic major.
*Insertion:* Into the angle of mouth.
*Action:* It expresses content.

**Zygomaticus Major (Figure 91):**
Origin - from zygomatic bone
Insertion - Angle of mouth.
*Action:* Muscle of smiling/laughing and is also known as the muscle of tetanus.

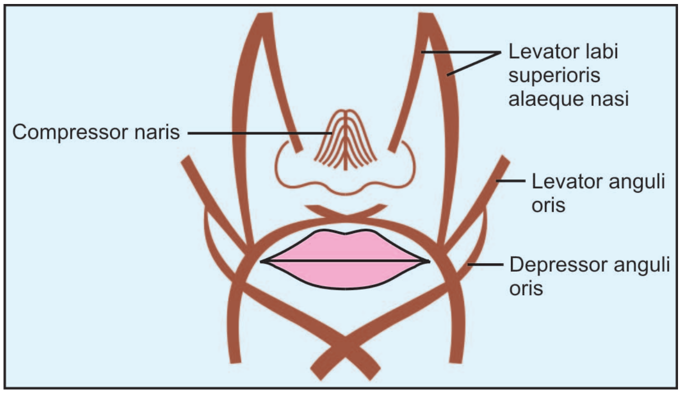



**Figure 91** Showing muscles of face

**Platysma (Figure 92):** Platysma arises from the deep fascia covering the pectoralis major and the deltoid. It has an additional attachment to overlying skin and fascia below the clavicle up to the level of second costal cartilage. It runs upwards and

forwards in the region of neck and enters the region of face. Here its horizontal fibres, running towards the angle of mouth are known as rizorius. Platysma is supplied by cervical branch of the facial nerve.

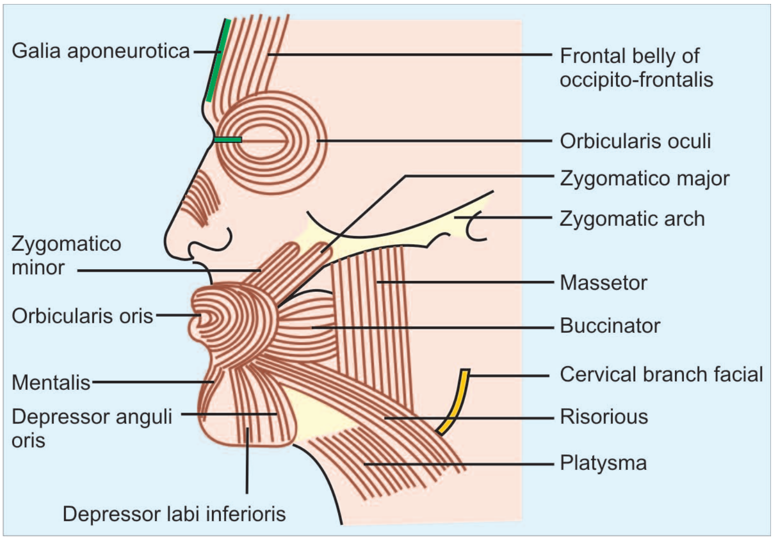



**Figure 92** Showing some muscles of face

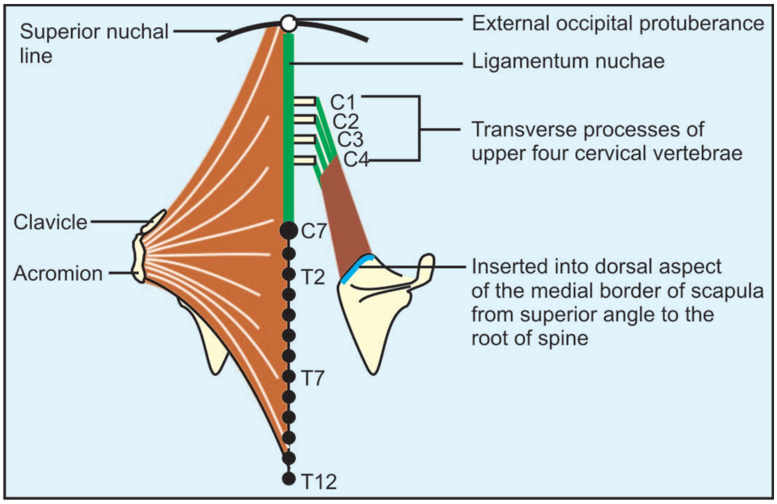
**Action:** It pulls the angle of mouth downwards and backward. Repeated voluntary contractions of the platysma reduces the wrinkles of the neck and helps in reducing the third chin. It is a muscle of horror.

**Clinical:** An axial pattern myocutaneous flap raised on the platysma muscle is a useful tool in reconstruction of cheek following surgery for trismus or malignancy and in reconstruction of lip and the pharynx.

# BACK OF THE NECK AND HEAD

**Trapezius:** Trapezius muscle arises from the medial one-third of the superior nuchal line, external occipital protuberance, ligamentum nuchae, seventh cervical spine and the tips of all the thoracic spines along with the supraspinous ligaments. Upper fibres are inserted to the posterior border of the lateral 1/3rd of the clavicle, middle ones get inserted into the medial border of acromion and the inferior fibers get inserted into the crest of the spine of the scapula. Lower fibres form a compact group at the root of the spine where a small bursa intervenes between the muscle and the bone (Figure 93).

**Figure 93** Showing origin and insertion of trapezius and levator scapulae muscles




**Nerve Supply:** It is supplied by the eleventh cranial nerve (spinal root), third and fourth cervical also supply the muscle, but they are propriocetive.

**Action:** Middle fibres draw the shoulder medially and backwards, upper fibres elevate, lower ones depress the shoulder. In addition to this, lower fibres help in scapular rotation with the help of levator scapulae muscle.

**Levator Scapulae (Figure 93):** Levator scapulae arises from the transverse processes of upper four cervical vertebrae. This muscle along with the rhomboidei, serratus-posterior and splenius, forms the member of the second group of muscles. It is inserted into the dorsal aspect of the medial border of the scapula from the superior angle to the root of the spine of scapula.

**Nerve Supply:** It is supplied by third and fourth cervical and also by the nerve to rhomboids.

**Action:** Main action is to fix the scapula or keep it steady during the movements of the limb. This muscle also helps in elevation and rotation of the scapula.

**Splenius Muscles (Figure 94):** Two muscles come under this name viz. splenius cervicis and the splenius capitis. Splenius mass takes origin from the lower part of ligamentum nuchae and the spines of the seventh cervical and upper six thoracic vertebrae. After the origin it soon divides into two, one going towards the neck and the other one towards the head.

**Splenius Cervicis:** It is inserted by tendinous slips into the transverse processes of the upper three or two cercial vertebrae. This muscle is overlapped by the levator scapulae.

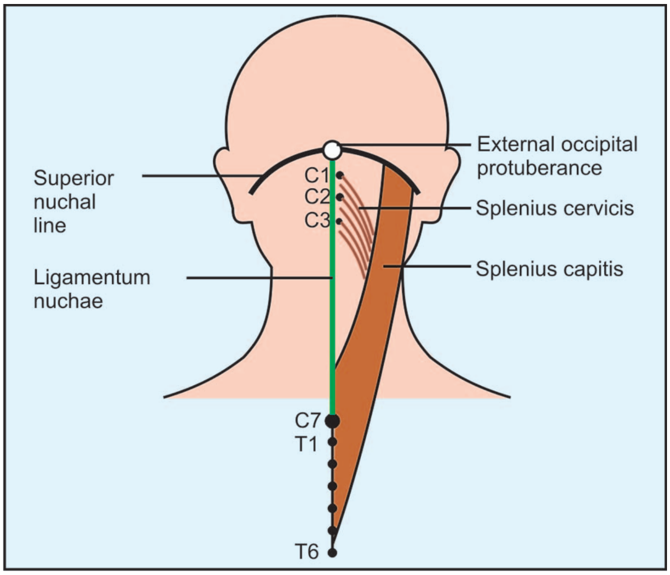



**Figure 94** Showing muscles of back of neck splenius capitis and splenius cervicis

**Splenius Capitis (see Figure 94):** It gets inserted into the lateral portion of the superior nuchal line and the mastoid process.

**Nerve Supply:** Dorsal rami of cervical nerves.

**Action:** It bends the head and neck backwards and towards the same side.

**Structures Under Cover of the Splenius Capitis (Figure 95):**

1. Occipital artery
2. Semispinalis capitis
3. Longissimus capitis
4. Obliquus inferior
5. Branches of dorsal rami of cervical nerves
6. Obliquus superior.

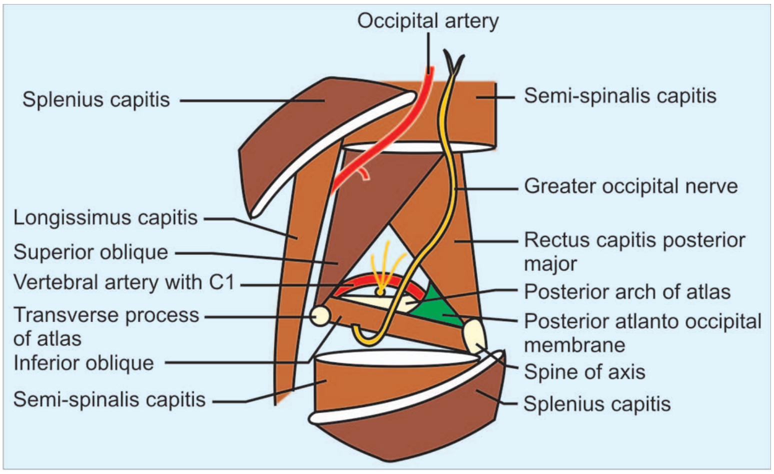



**Figure 95** Showing structures under cover of splenius capitis muscle. Please note the boundaries of the sub-occipital triangle

**Semispinalis capitis:** This muscle is thick enough to produce a rounded eminence on the back of the neck. It arises from the tips of the transverse processes of the upper six thoracic vertebrae, seventh cervical vertebra and from the articular processes of the fourth, fifth and sixth cervical vertebrae. It is inserted into the medial half of the area between the superior and inferior nuchal lines. Medial part of the muscle sometimes is more or less distinct from the rest of the muscle. It is named as spinalis capitis. As it is traversed by the imperfect tendinous intersection it is known as Biventar cervicis.

**Nerve Supply (see Figure 95):** By dorsal rami of the cervical and thoracic nerves.

**Action:** It extends the head and turns the face to the opposite side.

**Semispinalis Cervicis (Figure 96):** Origin is same as that of semispinalis capitis. It is inserted chiefly into the spine of the second cervical vertebra. On account of this, spine of the second cervical vertebra is stronger and thicker.

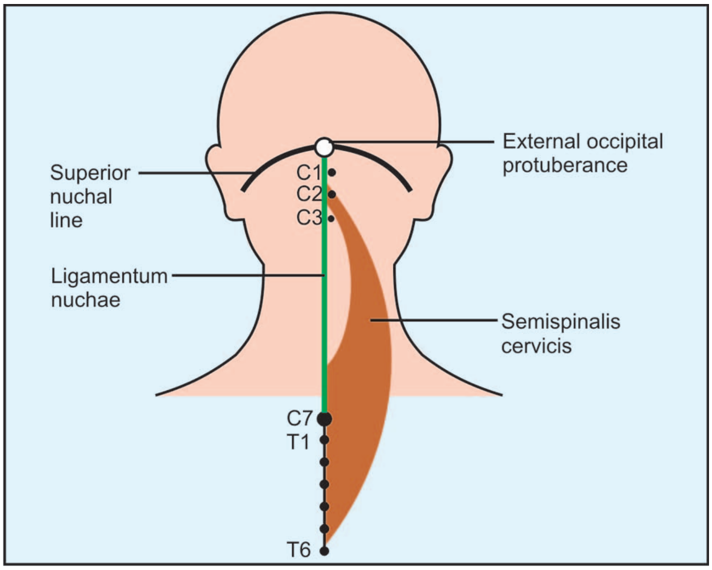



**Figure 96** Showing attachments of semispinalis cervicis muscle

**Longissimus Capitis: (Figures 97 and 98)** It is long and slender about the half the thickness of the finger. Because of this thinness it is considered as an important guide for the operating surgeon to know the depth he has reached. It arises from the transverse processes of upper four thoracic vertebrae and gets inserted into the back of the mastoid process under cover of the splenius capitis and the sternomastoid.

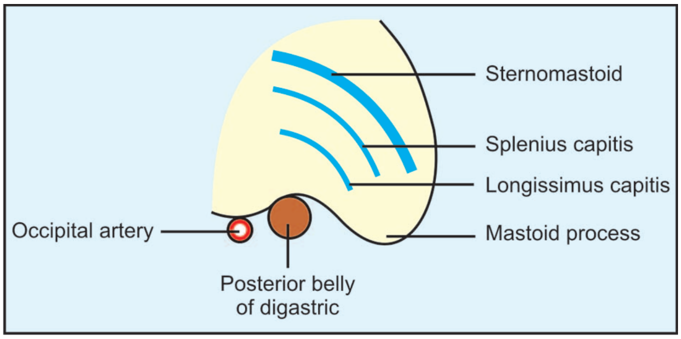



**Figure 97** Showing attachments of the mastoid process (diagrammatic)

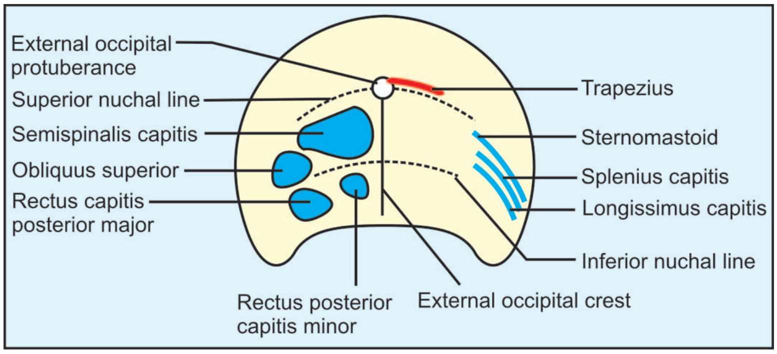



**Figure 98** Showing posterior view of the occipital bone

**Occipital Artery (Figure 99):** Occipital artery arises from back the external carotid artery at the level of facial artery in the carotid triangle, runs upwards and backwards along the lower border of the posterior belly of digastric muscle to the groove under the mastoid process. It escapes under the mastoid process and then follows the superior nuchal line, and goes to point on the back of the head. Here it pierces the trapezius muscle.

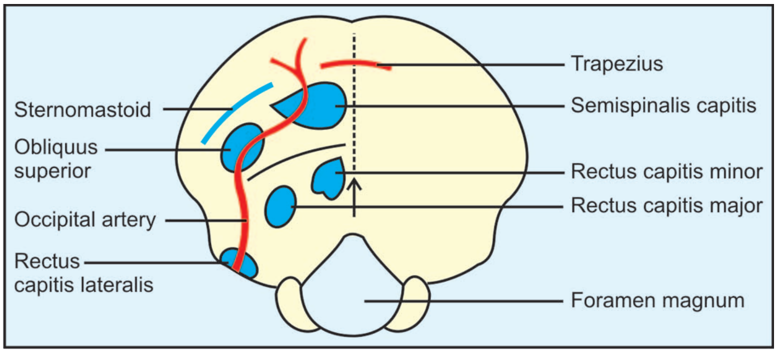



**Figure 99** Showing course of occipital artery in relation to the occipital bone and the muscle attached to it

From origin to the mastoid process is taken as first part. Part under the mastoid process and that one till it pierces the trapezius is taken as second part and one on the back of the head where it ramifies is taken as third part. First part runs along the lower border of the posterior belly of the digastric.

Now along with the posterior belly of digastric it passes superficial to all the structures in the carotid triangle which are under cover of the posterior belly of digastric. Second part is deeply placed. It is deep to mastoid process and muscles attached to it. (Sternomastoid, splenius capitis, longissimus capitis) and the posterior belly of the digastric (Figure 97). Sometimes, it passes superficial to the longissimus capitis. Next it passes through the apex of the posterior triangle and disappears under cover of the trapezius.

During the first part of its course it crosses internal carotid artery, internal jugular vein, vagus nerve, 12th nerve and the accessory nerve. During its second course it is covered by mastoid process, sternomastoid, splenius capitis, posterior belly of the digastric and the longissimus capitis as already mentioned. Further it lies on the rectus capitis lateralis, superior obliquus and the semispinalis capitis muscles.

It pierces the fascia between the trapezius and the sternomastoid muscles and appears with a wavy course in the superficial part of the scalp. Here, it is accompanied by the greater occipital nerve. It is must be kept in mind that the occipital artery is crossed by the hypoglossal nerve, superficially which winds round it from behind forwards at its origin.

# BRANCHES OF OCCIPITAL ARTERY

**Sternomastoid branches:**

a. *Lower sternomastoid branch:* Generally, arises from the occipital artery, but may arise from external carotid. It anastomoses with the sternomastoid branch of the superior thyroid artery.
b. *Upper sternomastoid branch:* Upper sternomastoid branch arises from the occipital artery as it crosses the accessory nerve and enters the deeper surface of the sternomastoid muscle along with the eleventh nerve.
   1. *Mastoid branch:* It is small and sometimes absent. It supplies the dura and the mastoid air cells. It anastomoses with the middle meningeal artery.
   2. *Auricular branch:* Supplies the back of the auricle and anastomoses with posterior auricular artery.
   3. *Muscular branches:* They are to the digastric, stylohyoid, splenius and longissimus capitis, muscles.
   4. *Descending branch:* Descending branch arises from the occipital artery as it lies on the obliquus superior muscle. It further divides into superficial and deep branches. Superficial branch anastomoses with the superficial branch of the transverse cervical artery and the deep branch anastomoses with the vertebral artery.
   5. *Meningeal branches:* They enter through the jugular foramen and the condylar canal and supply the dura mater of the posterior cranial fossa.
   6. *Occipital branches:* They are the terminal branches distributed to the scalp. One of the occipital branch may give a small meningeal branch which passes through the parietal foramen.
   7. *Deep cervical artery*

# LIGAMENTUM NUCHAE

**Ligamentum Nuchae (Figure 100):** Ligamentum nuchae is the triangular fibrous septum situated in the middle of the back of the neck. Its apex is situated at the spine of the seventh cervical vertebra. Anterior border is attached to the tubercle of the atlas and the spines of the rest of the cervicle vertebrae, while its posterior margin is free. Its base is situated at the external occipital crest. It is the posterior border gives origin to number of muscles.

**Deep Cervical Artery (Figure 100):** Deep cervical artery is a branch of the costocervical trunk. It passes upwards from the neck of the first rib to the point where it anastomoses with the descending branch of the occipital artery. During its ascend, it passes between the semispinalis capitis and the cervicis muscles. A big vein accompanies this artery, comes from the suboccipital plexus of veins and ends in the vertebral vein.

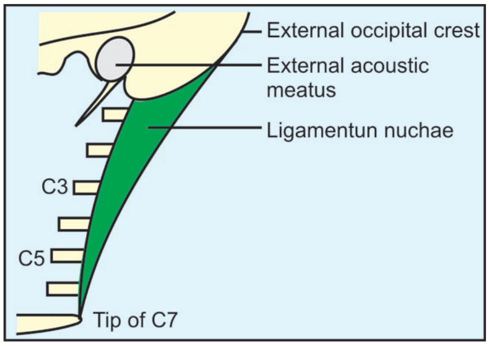



**Figure 100** Showing attachment of ligamentum nuchae

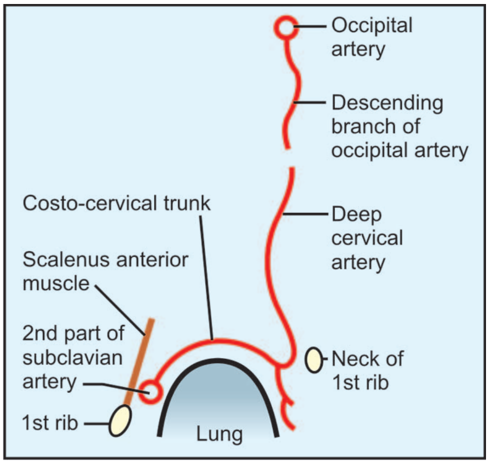



**Figure 100A** Showing descending branch of occipital artery and deep cervical branch of costo-cervical trunk (schematic)

# SUBOCCIPITAL TRIANGLE

It is situated at the back of the lower part of the head and the upper part of the neck. Supero-medial boundary is formed by rectus capitis posterior major supplemented by rectus capitis minor. Superolateral boundary is formed by superior obliquus muscle, and the inferolateral boundary is formed by inferior obliquus muscle.

**Roof is Formed by:** Splenius capitis, semispinalis capitis, longissimus capitis and semispinalis cervicis. Roof is crossed by greater occipital nerve which winds the lower border of inferior obliquue muscle.

**Floor (Figure 101):** Floor is formed by the posterior arch of the atlas and the atlanto-occipital membrane.

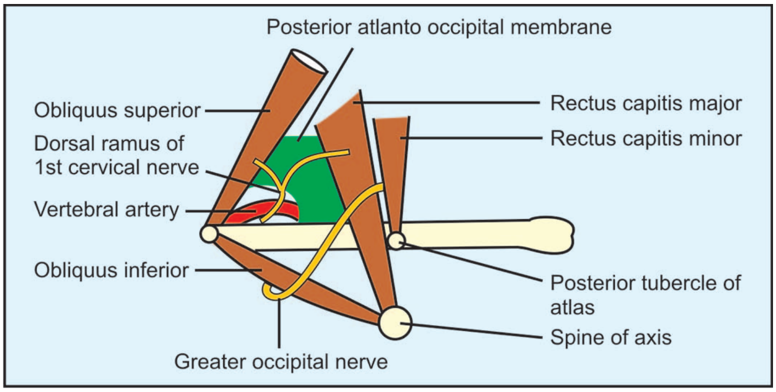



**Figure 101** Showing suboccipital triangle

**Contents:** Contents are – the vertebral artery, venous plexus and the dorsal ramus of the first cervical nerve.

**Dorsal Ramus of the First Cervical Nerve (Figures 102 and 103):** It enters the triangle by passing between the posterior arch of the atlas and the vertebral artery, and soon breaks into number of branches. There are five muscular branches give to:

- 2 recti rectus capitis posterior major and minor
- 2 obliquae obliquus superior and inferior
- Splenius capitis
- Communicating to greater occipital nerve
- Sometimes a cutaneous filament.

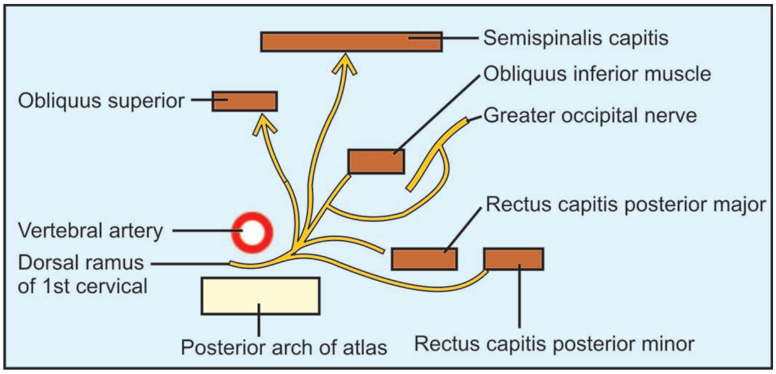
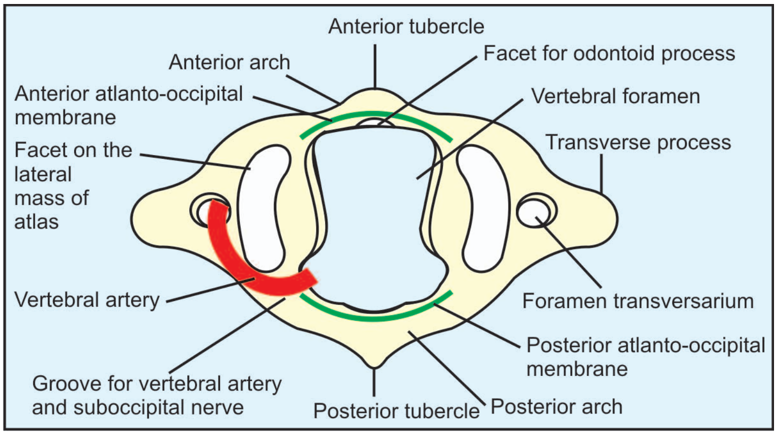



**Figure 102** Showing branches of dorsal ramus of 1st cervical nerve (Schematic). Note: that the communicating branch to greater occipital arises from nerve to obliquus inferior muscle

**Figure 103** Showing relation of the vertebral artery with atlas (seen from above)




The communicating branch to the greater occipital nerve arises from the nerve to the inferior oblique muscle. The cutaneous branch of it has to follow the occipital artery in order to supply the skin of the occiput.

**Vertebral Artery:** Third part of the vertebral artery lies in the suboccipital triangle. After its exit from the foramen of the transverse process of the atlas it runs backwards and medially to occupy the groove on the posterior arch of atlas. Soon it disappears under the posterior atlanto-occipital membrane. As it leaves the triangle, it pierces the dura-mater and enters the vertebral canal.

# SUBOCCIPITAL MUSCLES

**Rectus Capitis Posterior Major:** Rectus capitis posterior major arises from the spine of the axis and gets inserted into the lateral area below the inferior nuchi line. It pulls the head backwards and rotate on its own side.

**Rectus Capitis Posterior Minor:** The muscle arises from the tubercle of the posterior arch of the atlas and runs on the medial aspect of the major muscle for its insertion into the medial area below the inferior nuchal line. It pulls the head backwards.

**Obliquus Inferior:** Obliquus inferior arises from the spine of the axis and gets inserted into the transverse process of atlas. Please make it a point to remember that it is this muscle around whose inferior border the greater occipital nerve winds round. It can effect rotation of atlas and head to its own side.

**Obliquus Superior:** Obliquus superior arises from the transverse process of the atlas and gets inserted into the lateral part of area between the nuchal lines. It rotates the head to opposite side and when both of them act they tilt the head backwards.

**Greater Occipital Nerve:** Greater occipital nerve is the medial branch of the dorsal ramus of the second cervical nerve. It is the thickest cutaneous nerve in the body. After winding the inferior border of the inferior obliquus muscle it runs medially over the roof of suboccipital triangle. It pierces the semispinalis capitis, trapezius and ultimately appears one inch lateral to the external occipital protuberance in order to supply the skin.

**Third Occipital Nerve:** Fine cutaneous nerve arises from the medial branch of dorsal ramus of third cervical nerve. It supplies area of skin of the nape of the neck and the skin over the external occipital protuberance.

**Nerves of the Cervical Region:** Dorsal ramus of first cervical nerve does not divide into the medial and lateral branches and it seldom gives the cutaneous branch.

# DEEPER CONSIDERATION OF THE FACE

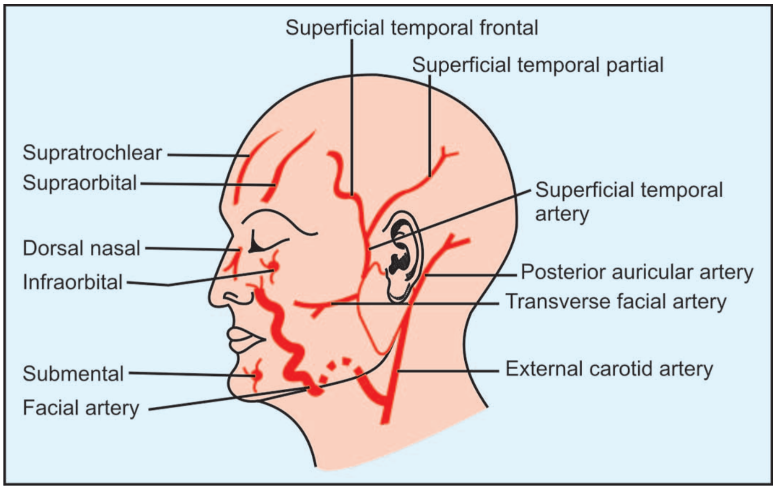
**Blood Supply of the Face:** Face is richly supplied with blood, therefore, wounds of the face bleed profusely and heal earlier.

**Arteries:**

1. Facial
2. Transverse facial branch of superficial temporal.
3. Few numerous twigs which appear in this region along with the branches of the trigeminal nerve.

**Facial Artery (Figure 104):** Facial artery arises from the external carotid artery in the carotid artery in the carotid triangle from anterior aspect of it. After its origin it runs upwards under cover of posterior belly of digastrics and stylohyoid muscle. Here it is related to the posterior pole of the submandibular salivary gland and it lies deep to it and next it comes to lie between the medial pterygoid muscle and the gland. Ultimately it gains the anteroinferior angle of the masseter muscle, pierces the deep fascia of the neck and enters the face. Here it runs a wavy course forwards and upwards one inch from the angle of the mouth. It ascends vertically in muscle (lavatory labii superioris oris alaeque nasi) and ends near the medial angle of the eye. It is deep to platysma, rizorious and Levator labii superioris Alaeqe nasi. It lies on the mandible, buccinators and levator anguli aris muscles.

**Figure 104** Showing arteries of the face (side view)




Following are the branches of the facial artery in the face:

- Superior labial artery
- Inferior labial artery
- Lateral nasal branch.

**Abnormally:** The facial artery may arises in common with the lingual artery.

**Surface Marking of the Facial Artery:** Please draw three points as suggested below.

1. Anterior inferior angle of masseter.
2. A point just above the greater cornu of the hyoid bone along the anterior border of sternomastoid muscle.
3. A point at the medial angle of the eye.

Join these points with a wavy course.

*Note:* The wavy course of the artery allows opening of the jaw freely without putting tension on the artery, during swallowing, talking and laughing.

**Veins of the Face :** It must be remembered that the facial veins are surgically important, because of the fact, that they have connections with the cavernus sinuses.

**Anterior Facial Vein (Figure 105):** It runs from the medial angle of the eye to the antero-inferior angle of the masseter muscle and lies posterior to the fascial artery. Supratrochlear and supraorbital veins unite to form the angular vein at the medial angle of the eye. Vein runs downwards and backwards first under cover of the zygomaticus major and then under rizorius, and platysma and comes to antero-inferior angle of the masseter muscle. Soon it joins the anterior division of posterior facial vein to form the common facial vein, which joins the internal jugular vein.

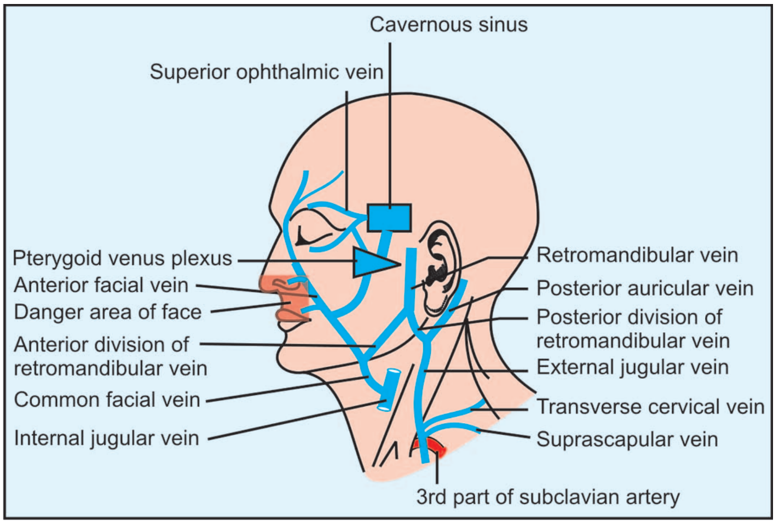



**Figure 105** Showing veins of the head and the neck including danger area face side view

**Important Intra-cranial Connections:** Through supraorbital and supratrochlear veins it makes connections with the ophthalmic veins which in its turn has a communication with cavernus sinus. The area of the face round the upper lip is known as the danger zone of the face as infection from this region can easily reach the cavernus sinus. Never press a boil in this zone as I know of a person who died due to cavernus sinus thrombosis. Anterior facial vein is connected by means of deep facial veins with the pterygoid plexus of vein which has a communication with the cavernus sinus. Pterygoid venous plexus is outside, in side and on the medial side of the muscle. By virtue of muscular contraction it pushes blood toward the cavernus sinus. Pterygoid venous plexus is known as peripheral venous pump, (Peripheral Heart) similar to the soleus muscle of the leg.

**Nerves of the Face (Figures 106A and B):** Ophthalmic division of the trigeminal nerve divides into three branches in the orbit namely the nasociliary, frontal and the lacrimal from medial to lateral side. Nasociliary gives external nasal and the infratrochlear; frontal gives supraorbital and supratrochlear and lacrimal gives palpebral branch for upper lid.

Figure 106A Showing cutaneous nerves of face and neck. Note that the superficial temporal artery and the auriculo-temporal nerve cross zygomatic arch superficially. Artery infront and nerve behind

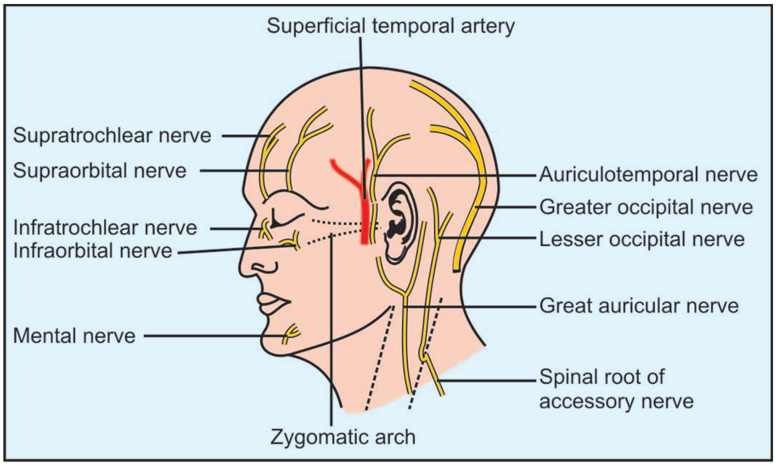
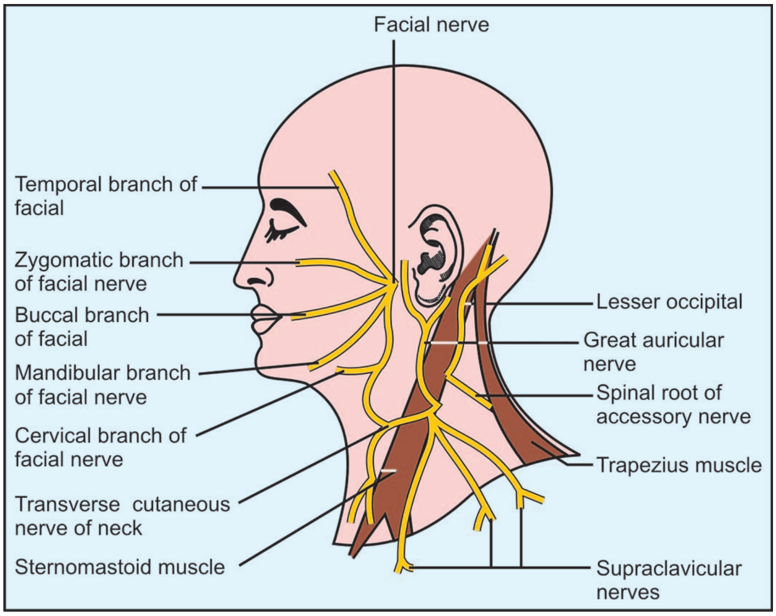



Figure 106B Showing cutaneous branches of the cervical plexus




**Maxillary nerve:** Maxillary nerve is the second division of the trigeminal nerve. It gives infraorbital as its terminal branch which enters the face through the infra-orbital foramen. In addition to this, maxillary nerve gives a zygomatic branch in the orbit which ultimately divides into zygomatico-facial and zygomatico-temporal nerves.

**Mandibular nerve:** Mandibular nerve is the third division of the trigeminal nerve. It gives auriculo-temporal, buccal and mental nerves.

**Nerve supply of the nose:** Upper half of the nose is supplied by the infratrochlear and the lower half including the tip of the nose is supplied by external nasal nerves. It must be remembered that both the nerves are the branches of the nasociliary nerve, the branch of ophthalmic division of trigeminal nerve.

**Palpebral branch:** Palpebral branch is the branch of the lacrimal nerve and supplies the lateral half of the upper lid.

**Infraorbital nerve:** Infra-orbital nerve enters the face after its exit through the infra-orbital foramen. It soon divides into three branches out of which one goes to upper lip, other goes to the nose and third one goes to the lower lid.

**Buccal nerve:** Buccal nerve is the branch of the mandibular nerve given in the infra-temporal fossa. It is sensory to the skin and the mucous membrane of the cheek and the lower part of the face between the symphysis and the masseter.

**Branches of the Facial Nerve (Figure 107):** It gives five branches which leave the parotid gland along its anterior border. They are as follows:

1. Temporal
2. Zygomatic,
3. Buccal
4. Mandibular and
5. Cervical
6. Zygomatic branch goes to the orbicularis oculi.

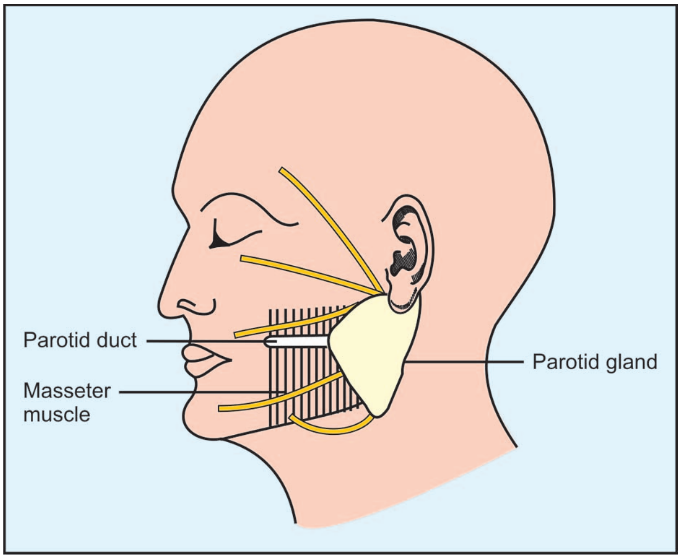



**Figure 107** Showing position of parotid gland. Note the parotid gland goes under the lobule of the ear posteriorly and overlaps masseter muscle anteriorly

**Temporal goes to the Temporal Region:** Lower members of the zygomatic group supply the muscles of the nose and other muscles which lie between the eye and the mouth. Buccal nerve supplies the muscle of the cheek. Mandibular branch supplies the muscles of the lower lip and the cervical branch supply the platysma. Cervical branch communicates with the anterior cutaneous nerve of the neck. Keep your right hand on the right side of the face with fingers spread-up in such a way that the thumb is at the temple and little finger crosses the mandible to reach cervical region. Index, middle and ring fingers indicate positions of zygomatic buccal and mandibular branches. Thumb indicates temporal branch while little finger cervical branch.

**Buccinator Muscle (Figure 108):** Buccinator muscle takes origin from outer surface of the maxilla and the mandible opposite the sockets for the molar teeth. The middle fibres arise from pterygomandibular raphae. Upper fibres go to the upper lip and lower to the lower lip. Middle fibres run forwards to the angle of the mouth where they decusset.

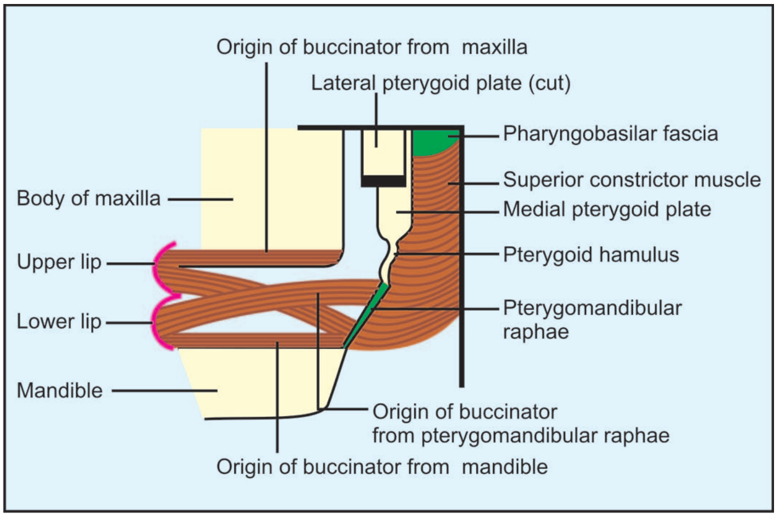



**Figure 108** Showing buccinator muscle. Note the fibers arising from the pterygomandibular raphae cross each other to reach upper and lower lips (diagrammatic)

**Action (Figure 109):** It is useful during mastication. It presses the cheeks against the teeth, preventing the food particles from occumulates in the vestibule of the mouth. It is the rinser's muscle. Rincing action is probably the most useful function of the buccinator. As you begin your day the buccinator (Rincing the mouth on getting up in the morning). It helps in sucking, blowing and whistling. It can be called glass blower or trumpheters professional muscle.

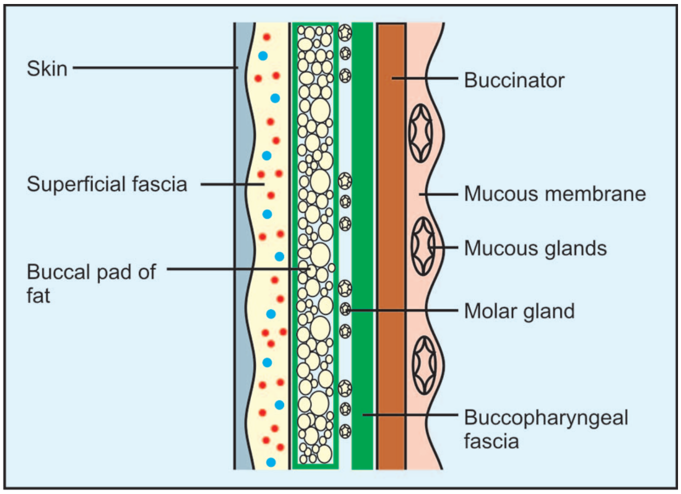



**Figure 109** Showing structure of cheek

**Buccopharyngeal Fascia:** Buccopharynbgeal fascia is thin, well defined fascia covering the buccinator anteriorly and the superior constrictor posteriorly. Pterygomandibular raphae extends from the tip of the pterygoid hamulus to the area of mandible behind the last molar tooth. It is considered as an union of buccinator anteriorly and superior constrictor posteriorly.

**Molar Gland (Figure 110):** Small mucous glands are situated over the buccopharyngeal fascia where the parotid duct pierces. Parotid duct pierces the buccopharyngeal fascia, buccinator and the mucous membrane opens into vestibule of mouth at the level of the upper second molar after running under mucosa for a short distance. Last course of the parotid duct under the mucous membrane of the mouse acts as the pressure valve during increase in oral pressure and closes the opening of the duct.

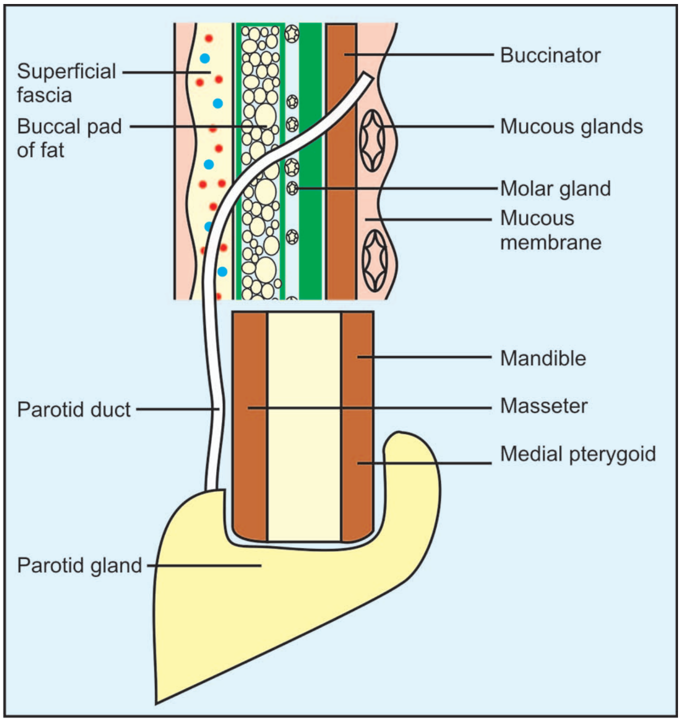



**Figure 110** Showing course of parotid duct

**Buccal Pad of Fat:** Buccal pad of fat is known as a "Sucking pad". It is the collection of fat enclosed in the facial capsule. It is packed between the buccinator and masseter muscles.

The pad is pierced by nerves, vessels and the parotid duct. It resists the atmospheric pressure and helps in sucking. It is well developed in infants for the obvious reason.

**Labial and Buccal Glands:** Small mucous glands under the mucous membrane of the lips open into the vestibule of mouth through their ducts.

**Buccal Salivary Gland:** They are mucous glands in the mucous membrane of the cheek. They may be found over the palate and give rise to ectopic salivary tumors (Sharma KD, MCN, Nagpur).

# PAROTID REGION

**Parotid Gland (Figure 111):** Parotid gland is the largest salivary gland belonging to compound racemose mixed type. It is situated at the side of the face below the external auditory meatus. Lower down it extends beyond the angle of the mandible, overlaps posterior belly of digastric and carotid triangle. Anteriorly it lies over the masseter and posteriorly over sternomastoid muscles. It is placed behind the mandible and infront of the mastoid process. Medially it is related the styloid process and styloid group of muscles. It may reach as far as the pharynx.

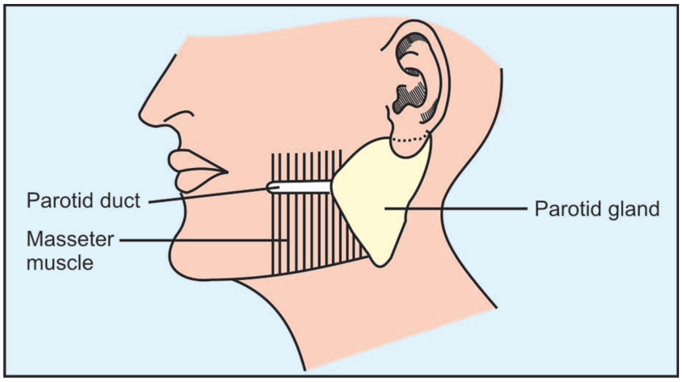



**Figure 111** Showing position of parotid gland

**Accessory parotid:** Accessory parotid is the small detached portion of the parotid gland lying in front and above the parotid duct, on the masseter.

**Shape:** Parotid gland is pyramidal in shape. Base is directed upwards and is in contact with external auditory meatus, while the apex directed downwards and overlaps the carotid triangle. It has superficial and the deep parts. Deep part is wedged in between the mandible infront and the mastoid process behind.

*Weight:* 25 to 30 gm.

**Parotid space: (Figure 112)** Parotid space is the space at the base of the skull. It is bounded by the posterior border of the ramus of the mandible infront and the mastoid process behind. The other structure forming it limit can be enumerated as under.

1. Sternomastoid
2. Posterior belly of the digastric
3. Stylomastoid foramen
4. Styloid process
5. Spine of sphenoid.
6. Foramen spinosum
7. Foramen ovale
8. Lateral pterygoid plate and
9. The scaphoid fossa.

*Surfaces:* It has four surfaces - Superior
- Superficial
- Antero-medial
- Postero-medial

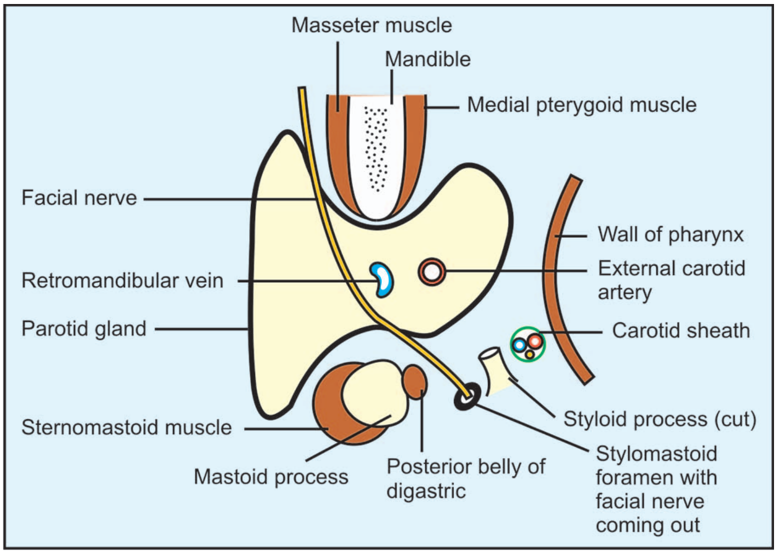



**Figure 112** Showing horizontal section of the parotid gland with relations of antero-medial and postero-medial surfaces

**Superior Surface:** Superior surface is the smallest surface pointing above and is in contact with the external auditory meatus. Through the superior surface, the superficial temporal artery and the auriculo-temporal nerve emerge. Superficial temporal artery is in front of the auriculo-temporal nerve (A – is Anterior).

**Superficial Surface:** It covers the the side of the face. It has few small lymph nodes and branches of the great auricular nerve. Along its anterior border, emerge branches of the facial nerve and the parotid duct.

**Antero-medial Surface:** Antero-medial is related with the lateral surface of the masseter, posterior border of the ramus of the mandible, medial pterygoid muscle and the lateral aspect of the temporo-mandibular joint. It must be remembered that the maxillary artery and branches of facial nerve leave through this surface. (Five M and one F).

1. Masseter
2. Mandible
3. Medial pterygoid
4. Mandibular joint (Temporo-mandibular joint)
5. Maxillary artery and
6. The branches of the facial nerve.

**Postero-medial Surface:** Postero-medial surface is related to large number of structures, i.e. mastoid process, sternomastoid, posterior belly of digastric, stylomastoid foramen with facial nerve, styloid process and muscles attached to it. Styloid process and the muscles separate the parotid gland from the carotid sheath the eleventh and twelfth cranial nerves. Two grooves are seen on the postero-medial surface of the parotid gland. The anterior one is meant for the retromandibular vein and the posterior for the external carotid artery. Facial nerve and the external carotid artery enter through this surface.

**Structures in the Substance of Parotid Gland:**

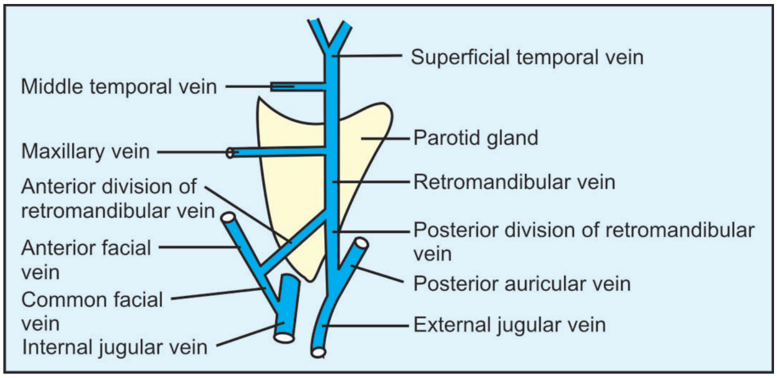
1. Facial nerve and its branches.
2. Communicating branches from the great auricular and auriculo-temporal nerves to the facial.
3. Retromandibular vein: It lies superficial to the artery.
4. External carotid artery: It lies deep to the retromandibular vein.
5. The lymph nodes.

**External Carotid Artery:** External carotid artery gives the posterior auricular branch before its entry in the substance of the gland. At the level of the neck of the mandible the external carotid artery divides into two terminal branches, superficial

temporal and the maxillary. Superficial temporal artery, under cover of the gland gives the transvers facial and the middle temporal branches.

**Retromandibular Vein (Figure 113):** Retromandibular vein is formed by the union of superficial temporal vein and the maxillary vein. It divides into the anterior and the posterior divisions (like an artery). Anterior and posterior divisions come out of the parotid through the lower pole. It has already been mentioned that the anterior facial and the anterior division of the retromandibular veins unite to form the common facial vein, which join the internal jugular. Posterior division of the retromandibular vein unites with the posterior auricular vein to form the external jugular vein at the lower pole of the parotid.

**Figure 113** Showing formation of retromandibular, common facial and the external jugular veins




**Facial Nerve:** After coming out of the stylomastoid foramen it enters the postero-medial surface of the parotid gland. Normally it passes superficial to the retromandibular vein and the external carotid artery. It may pass in between the retromandibular vein and the external carotid artery. Within the gland it divides into five branches, out of which 4 leave the gland along its anterior margin and the 5th one comes out of the gland at the lower pole (Cervical branch).

**Parotid Nodes (Figure 115):** They are present in two groups, i.e. within the substance and other on the superficial surface. Nodes on the superficial surface, drain the area of the auricle, scalp and the upper part of the face. Nodes in the substance of the parotid, drain external auditory meatus, middle ear, pharyngotympanic tube, nose, the palate and the deep part of cheek.

**Clinical:** Superior part of the gland is wedged in between the back of the temporomandibular joint and the external auditory meatus, as the gland is occupying the non-articular part of the mandibular fossa. During inflammation of the gland, opening of the lower jaw gives pain as the wedged part of the gland is compressed.

**Parotid Sheath:** As the investing layer of the fascia of the neck meets the lower pole of the parotid gland it splits into two layers namely the superficial and the deep. Superficial layer covers the superficial surface of the gland and gets attached to the zygomatic arch while the deeper one covers the deep surface. The superficial layer, which covers the masseter and the part of the gland is known as the parotido-masseteric fascia. Deep layer has two special condensations namely the sphenomandibular and the stylomandibular ligaments. Sphenomandibular ligament is attached to the spine of the sphenoid above and the lingula of the mandible below. It is pierced by the mylohyoid nerve and vessels. Stylomandibular ligament is attached to the styloid process above and the angle of the mandible below. Stylomandibular ligament separates the posterior pole of the submandibular salivary gland from the lower pole of the parotid.

**Parotid Duct (Stensen's Duct) (Figure 115):** Parotid duct is also known as Stensen's duct. It is 5 cm in length. It begins in the substance of the anterior part of the gland, leaves the anterior border and runs anteriorly on the masseter muscle. It receives the duct from the accessory parotid when present. At the anterior border of the masseter it turns medially and takes right angle bend, pierces the buccal pad of fat and the buccinator muscle. Before opening into the vestibule of the mouth at the level of the upper second molar, it runs obliquely forwards between the buccinator and the mucous membrane of the mouth. Above and below the duct, are the upper and the lower buccal branches of the facial nerve. Buccal branch of the mandibular nerve lies below the duct at the anterior border of the masseter and may even cross the duct. Transverse facial artery lies above the duct along with the accessory parotid gland.

Figure 114 Showing course of parotid duct

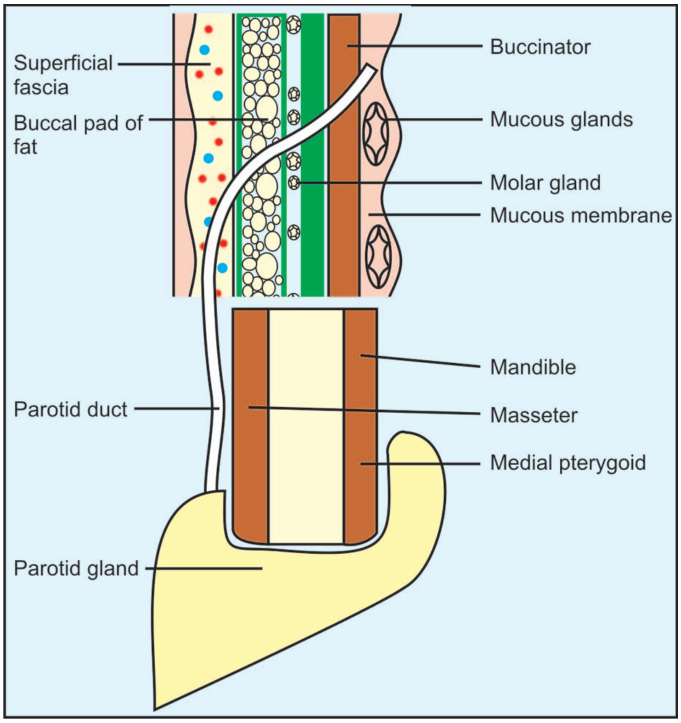
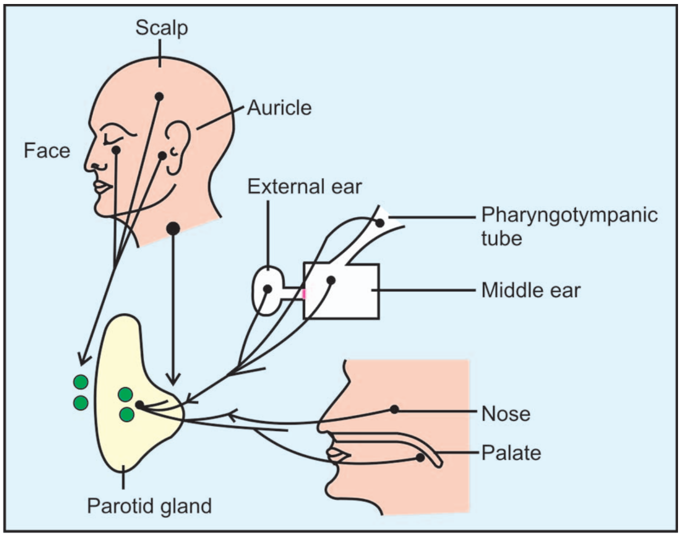



Figure 115 Showing superficial and intraparotid nodes with drainage area

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***Stensen:*** *A physician priest of Copenhagen was an anatomist, physiologist, and geologist who discovered the duct in the sheep.*

**Blood Supply of the Parotid Gland:** External carotid artery and its branches near by supply the gland. Veins from the parotid go to the internal jugular through the common facial vein. The posterior division of the retromandibular vein units with the posterior auricular vein to form the external jugular vein, which joins the subclavian vein behind the clavicle.

**Nerve Supply:** Parotid facia is supplied by great auricular nerve.

**Parasympathetic/ Secretomotor Nerve Supply of the Parotid Gland:** The secretomotor fibres for the gland come from the inferior salivary nucleus through the tympanic branch of 9th which enters the tympanic cavity, forms the tympanic plexus and leave as the lesser superficial petrosal nerve The lesser superficial petrosal nerve escapes through the cranial cavity through the foramina innominata. It joins the otic ganglion where the fibers are relayed. The post-ganglionic fibers leave the otic ganglion to join one of the roots of the auriculotemporal nerve. It is the auriculotemporal nerve which supplies the parotid gland. It is worth remembering here that the two root of the auriculotemporal nerve encircle the middle meningeal artery under cover of the lateral pterygoid muscle. Auriculotemporal nerve passes lateral to the spine of sphenoid. Auriculotemporal is sensory nerve which supplies the temporal region therefore the rapid enlargement of the parotid swelling causes pain in the temporal region. The temporo-mandibular joint is supplied by the auriculo-temporal nerve and it has a communication with the facial nerve (Figure 116).

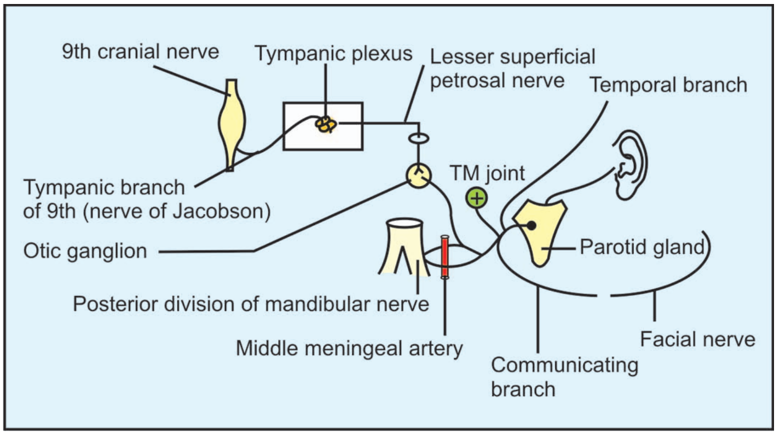



**Figure 116** Showing secretomotor nerve supply of parotid gland and branches of auricular temporal nerve

**Development:** Parotid gland is ectodermal in origin. It develops from the primitive angle of mouth in the form of a groove which gets converted into the duct. The posterior end of the duct divides repeatedly in the substance of the cheek to form the parotid gland. As the fusion of the mandibular and the maxillary arches takes place the anterior end of the duct gets shifted posteriorly.

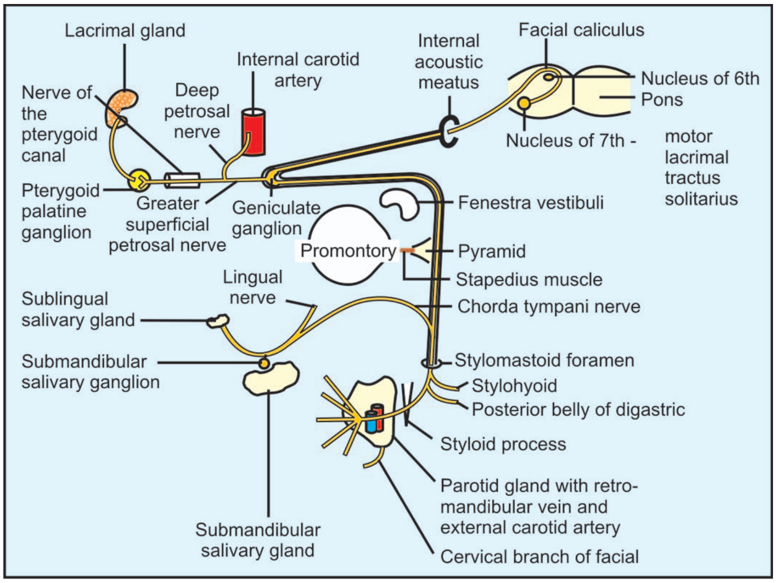
**Siolography:** Siolography is a special type of investigation for the radiographic visualization of the parotid duct and branching. A small canula is passed in the duct (Parotid or submandibular) and lipiodol (a radio-opaque substance) is injected through it. The x-ray is taken which shows the pattern of respective ducts.

**Parotid Duct in the Siologram:** The parotid duct is formed at the middle of the posterior border of the ramus of the mandible, by the union of the upper and the lower ducts which meet at right angle. The picture of the duct is well marked at the point where the duct pierces the buccinator muscle, which is due to the contraction of the buccinator.

**Facial Nerve (Figure 117):** It comes out of the pons at its lower border and enters the internal auditory meatus along with the 8th nerve. It courses through the temporal bone

taking an intricate course. It passes laterally above the vestibule of the internal ear and reaches the medial wall of the middle ear. Its horizontal course is directed posteriorly above the promontory and the fenesta vestibuli. It runs downwards behind the pyramid where it gives the branch to the stapedius muscle. Its further course is in the vertical part of the canal where it gives the chorda tympani nerve. The chorda tympani nerve enters the middle ear cavity through the posterior canaliculus crosses the flaccid part of the tympanic membrane and leaves through the anterior canaliculus. Facial nerve leaves the skull through the stylomastoid foramen and crosses the styloid process and the muscles attached to it. It crosses the internal jugular vein from the lateral aspect to enter the postero-medial surface of the parotid gland. During its course through the parotid gland, it crosses superficial to the external carotid artery and the retromandibular vein. It divides into 5 branches namely the temporal, zygomatic, buccal, mandibular and the cervical.

**Figure 117** Showing course and distribution of facial nerve intra- and extracranial




**Clinical:**

1. *Parotid fascia:* Fascia over the parotid is tough and is supplied by the great auricular nerve. Because of the tough fascia, fluctuations cannot be obtained even in the presence of the pus.
2. *Parotitis:* Inflammation of the parotid gland is known as parotitis. In mumps the parotid swelling is painless. It must be remember that in mumps the testes are affected which may cause testicular atrophy causing sterility. Bacterial parotitis is the result of bacterial infection reaching the gland through the duct. In case of infections of the oral cavity the incidence of parotitis is more due to reduced salivary flow in prolonged illness due to the blockage of the parotid duct.
3. *Parotid abscess:* Parotid abscess is very painful due to the tough sensitive parotid fascia. Fluctuations cannot be obtained due to the tough non yielding fascia, unless the fascia perforates. Parotid abscess is opened by giving a verticle incision starting infront of the tragus curved below the lobule of the ear and carried forwards over the mastoid around the posterior aspect of the lower pole of the parotid. Finally the pus is drained by thursting the mosquito forceps into the abcess.
4. *Tumours of parotid:* Tumours of the parotid can be benign or malignant. A slow growing benign tumour may undergo malignant change involving the facial nerve. A swelling of the parotid with facial nerve

involvement is the sure sign of malignancy. Testing the facial nerve function mandatory.

Testing the integrity of facial muscle is simple.

Ask the patient to

1. To wrinkling the forehead
2. Close the eyes
3. Show the teeth.

Commonest tumour of the parotid gland is the mixed salivary tumour, which mostly occurs in the superficial lobe of the gland. It can be excised by following the facio-venous plane, without damaging the facial nerve.

**Dumbell Tumour of the Parotid :** The tumour from the deep part of the gland may extend towards the pharynx through the gap between the mandible and the styloid process. It cannot be seen or felt from out-side.

**Frey's Syndrome:** Surgery on the parotid gland can damage the auriculotemporal and the great auricular nerves. During regeneration the damaged nerves get connected. As a result when the patient takes food, instead saliva pouring in the mouth, sweating of the skin over the parotid occurs. The condition is also known as gustatory sweating.

**Method of Fascial Nerve Tracing:** The facial nerve is exposed in an angle between the bone of the external acoustic meatus and the mastoid process. By following the nerve through the facio-venous plane the tumour of the superficial lobe can be excised without damaging the facial.

**Sjogren's Syndrome:** It is characterized by dry eyes dry mouth and rheumatoid arthritis. When the dry mouth and the eyes are the only of signs known as Sicca Syndrome.

**Mikuliez Disease:** There is symmetrical enlargement of the salivary glands, narrowing of the palpebral fissures and the dryness of the mouth. (END) E- enlargement, N- narrowing, D – dryness.

I remember what is often said about the Mikuliez disease is as under:

Mikuliez disease was seen and dignosed by Mikuliez himself and thereafter nobody i.e. the END of the disease. I did not find the description of the Mikuliez disease in the recent surgical texts.

**Siosis:** There is enlagement of the salivary gland due to metabolic disorder or the hormonal imbalance such as in diabetes and in acromegaly.

# TEMPORAL AND INFRATEMPORAL REGIONS

**Temporal Fascia:** Superiorly it is attached to the superior temporal line, a little beyond the origin of temporalise muscle. Lower down, it splits into two laminae, superficial and deep. Superficial lamina is attached to the upper border of the zygomatic arch and the deeper one is continuous with the fascia on the deeper surface of the masseter. The small potential space between the two laminae contains branches of superficial temporal artery and the branch of zygomatico-temporal nerve and some amount of fat, which is more in the lower part and gives opaque appearance to the temporal facia in the lower part. It may give us an impression that we have reached the skull as the opaque fascia looks like bone.

**Masseter Muscle (Figures 118 and 119):** Masseter muscle has two parts, superficial and deep. Deeper fibres are arranged vertically and the superficial fibres run downwards and backwards. The muscle arises from the lower border of the zygomatic arch and the deep surface of it. It is inserted into the lateral surface of the ramus and the coronoid process, of the mandible. Head and the neck of the mandible are not covered with the fibres of this muscle.

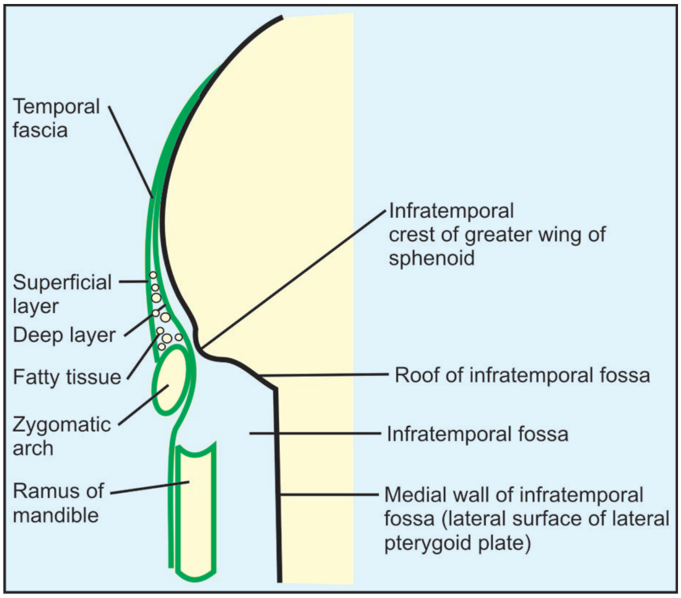



**Figure 118** Showing temporal fascia and the infratemporal fossa (coronal section)

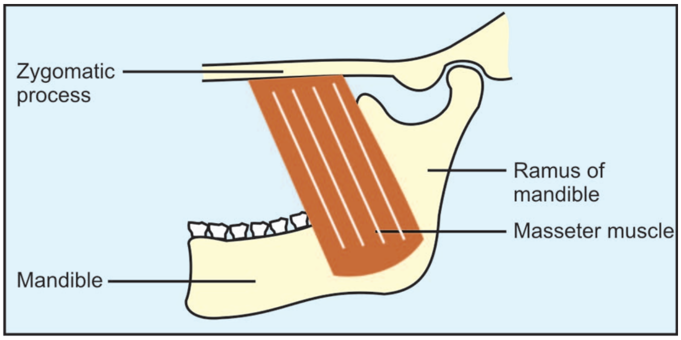
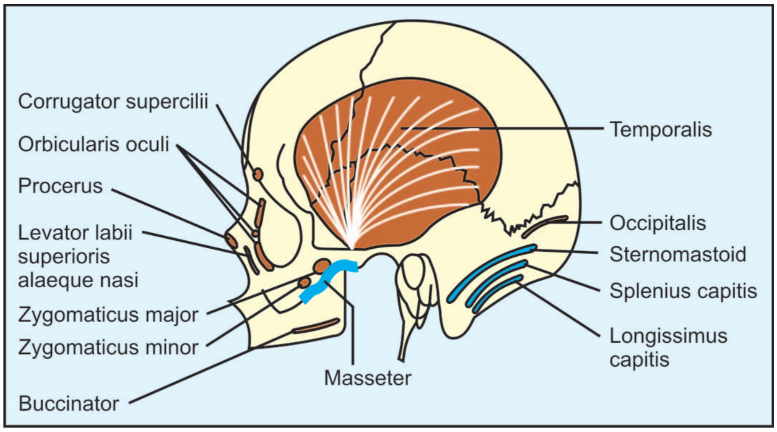



**Figure 119** Showing origin and insertion of masseter

**Action:** It elevates and protracts the mandible.

**Nerve Supply:** It is supplied by the mandibular nerve as other muscles of mastication.

**Temporalis (Figure 120):** Temporalis muscle arises from the temporal fossa and the temporal fascia to some extent. Anterior fibres run vertically downwards the posterior fibres run horizontally forwards towards the coronoid process for the insertion and the middle fibres are oblique. Superficial part is inserted into the anterior edge of the coronoid process and the anterior margin of the ramus of the mandible. The deeper fibres get inserted into the medial surface of the coronoid process.




**Figrue 120** Showing norma lateralis

**Action:** Temporalis muscle does the elevation and the retraction of the mandible.

**Nerve Supply:** Temporalis muscle is supplied by the deep temporal branches of the mandibular nerve. It is one of the muscle of mastication and is developed from the first arch.

**Superficial Contents of the Infratemporal Fossa (Figure 121):** Following structures are seen

1. Lateral pterygoid muscle.
2. Medial pterygoid muscle.
3. Maxillary artery.
4. Pterygoid venous plexus.
5. Maxillary veins which run backwards and end in the retro-mandibular vein.

**General Arrangement of the Structures:** Lateral pterygoid muscle has to heads, upper and lower. It is roughly triangular in shape with the base directed anteriorly and the apex posteriorly at the neck of the mandible. Fibres are directed horizontally backwards.

Medial pterygoid muscle also, has two heads, the superficial and the deep. Deep head lies deep to the lower head of the lateral pterygoid muscle and the superficial head lies superficial. In other words, superficial and deep heads are seen embracing the lower head of the lateral pterygoid muscle, like two tongs of the fork holding the meat sandwich. The two heads meet and run downwards and backwards for its insertion into the medial aspect of the ramus of the mandible between the angle and the lingula. Separate maxillary artery is one of the two terminal branches of the external carotid artery given at the level of the neck of the mandible in the substance of the parotid gland other being the superficial temporal. It runs forwards, below the lower head of the lateral pterygoid muscle and next lies on the surface of the lower head of the lateral pterygoid. At times it passes deep to the lower head of the pterygoid and peeps through the interval between the superior and the inferior heads of the lateral pterygoid muscle. Further it enters the pterygomaxillary fissure and reaches the pterygo-palatine fossa.

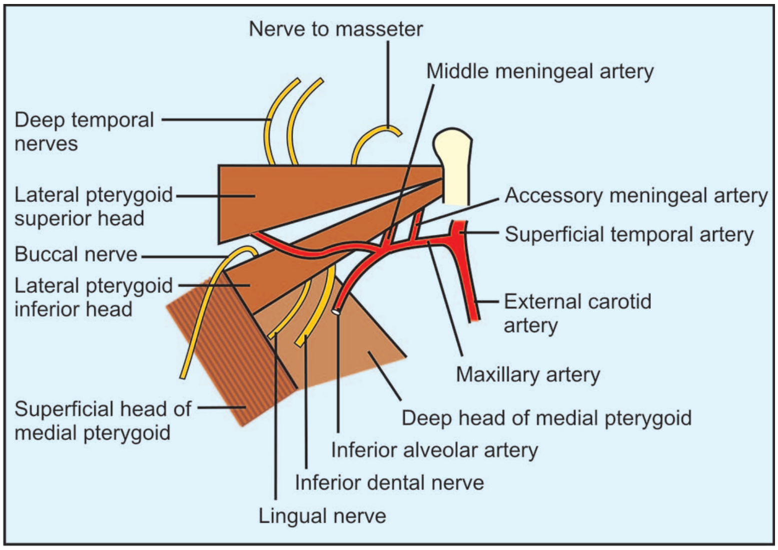



**Figure 121** Showing some of the relations of lateral pterygoid muscle

**Pterygoid Plexus of Veins:** Pterygoid venous plexus is formed by the veins corresponding to the branches of the maxillary artery. It lies superficial and deep to the lateral pterygoid muscle. It also occupies the substance of the muscle. Muscular contraction pushes blood towards the cranial cavity, in general and the cavernous sinus in particular. Hence, the lateral pterygoid is known as the peripheral heart like the soleus muscle of the lower limb. The maxillary vein begins at the posterior end of the pterygoid venous plexus and accompanies the first part of the maxillary artery. It joins the superficial temporal vein to form the retro-mandibular vein. Only the first part of the maxillary artery has the accompanying vein i.e. maxillary vein.

**Sphenomandibular Ligament:** Sphenomandibular ligament lies deep to the lateral pterygoid muscle. It is attached to the spine of the sphenoid above and the lingula of the mandible below. It is seen at the lower border of the lateral pterygoid muscle. Lower down it lies on the medial pterygoid muscle. It is pierced by the mylohyoid nerve and the vessels.

General description of the relations of the lateral pterygoid muscle as seen in the fossa:

A. Structures at the upper border of the lateral pterygoid:
   1. Nerve to masseter.
   2. Two deep temporal nerves which supply the temporalis.
B. Structures at the lower border of the lateral pterygoid muscle:
   a. Medial pterygoid muscle.
   b. Maxillary artery
   c. Lingual nerve
   d. Inferior alveolar and its mylohyoid branch and vessels.
   e. Middle meningeal artery.
   f. Accessory meningeal artery when present.
   g. Maxillary vein.
C. Structures in between the two heads of the lateral pterygoid muscle:
   1. Maxillary artery
   2. Buccal nerve

At this stage one can see, the small part of the maxillary nerve and its two branches namely the zygomatic and the posterior superior alveolar through the pterygomaxillary fissure.

**Lateral Pterygoid:** Lateral pterygoid muscle has two heads. Superior one arises from the infra-temporal ridge and the infra-temporal surface of the greater wing of

the sphenoid. Inferior head arises from the lateral surface of the lateral pterygoid plate. Both the heads meet and run posteriorly for its insertion into front to the neck of the mandible over the fovea, capsule of the temporo-mandibular joint and the articular disc.

**Action:** The lateral pterygoid muscle is the depressor and protractor of the mandible.

**Nerve Supply:** It is supplied by the branch from the mandibular nerve.

Brief review of the relation of the lateral pterygoid is consider necessary:

Lateral pterygoid muscle is considered as the key muscle of intratemporal fossa.

**Superficial Relations:** Bone - Ramus of mandible
Muscle - Temporalis and masseter.
Artery - Maxillary.

**Deep Surface is Related to :** Muscle - Medial pterygoid, tensor palati
Nerve - Mandibular nerve its trunk and two division, otic ganglion, nerve spinosus auriculotemporal nerve.
Ligament - Sphenomandibular ligament.
Artery - Middle and accessory maningeal arteries.

**Structures at the Upper Border:** Structures at the upper border are deep temporal nerve and nerve to masseter.

**Structures at the Lower Border** Maxillary artery, lingual nerve, spheno-mandibular ligament, nerve to mylohyoid and the inferior alveolar vessels and nerve and the deep head of the medial pterygoid muscle.

**Medial Pterygoid Muscle (Figure 122):** Medial pterygoid muscle has two heads, the superficial and the deep. Superficial head arises from the maxillary tuberosity of maxilla and the deep arises from the medial surface of the lateral pterygoid plate. Deep head of the medial pterygoid is under the lower head of the lateral pterygoid. The superficial head of the medial pterygoid is superficial to the lower head of the lateral pterygoid muscle. The superficial and the deep heads of the medial pterygoid muscle catch the lower head of the lateral pterygoid muscle. Two heads after embracing the lower head of the lateral pterygoid muscle unite and run downwards and backwards for insertion into the area between the angle of the mandible and the lingula on the medial surface of the ramus of the mandible.

**Action:** Medial pterygoid is an elevator and the proctractor of the mandible. It is supplied by the mandibular nerve.

We have seen that the two pterygoids, temporalis and the masseter are the muscles of the mastication. All are supplied by the mandibular nerve – the nerve of the first arch. The muscles of mastication are derived from the first pharyngeal arch.

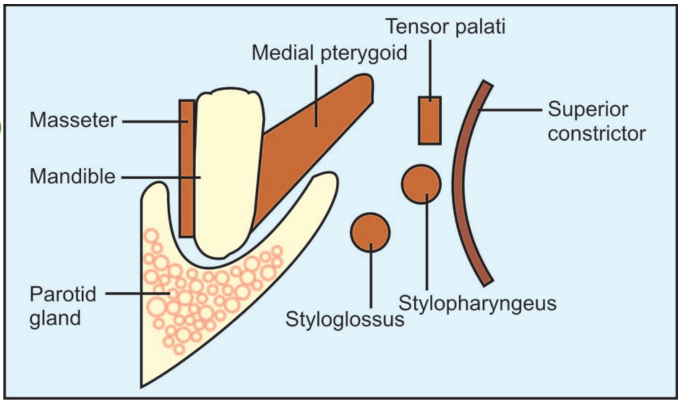



**Figure 122** Showing medial relations of medial pterygoid muscle (horizontal section) (diagrammatic)

## Relations of Medial Pterygoid Muscle

**Medial Relation (Figure 122):** Medial pterygoid muscle is separated from the superior constrictor muscle by the stylopharyngeus and styloglossus muscles and the tensor palate muscle.

**Lateral Relations:**
Ramus of the mandible
Lateral pterygoid muscle.
Sphenomandibular ligament
Maxillary artery
Lingual nerve, inferior alveolar nerve to mylohyoid, inferior alveolar artery and its mylohyoid branch.
Process of parotid gland.

**Maxillary Artery (Figures 122A to C):** The maxillary artery is the main artery of this region. It arises as one of the two terminal branches of the external carotid artery at the level of the neck of the mandible in the substance of the parotid gland. It runs either superficial or deep to the lower head of the lateral pterygoid muscle and enters the pterygomaxillary fissure by passing beeween the two heads of the muscle. Course of the Maxillary artery is divided into three parts.

1. Mandibular
2. Pterygoid
3. Pterygo-palatine.

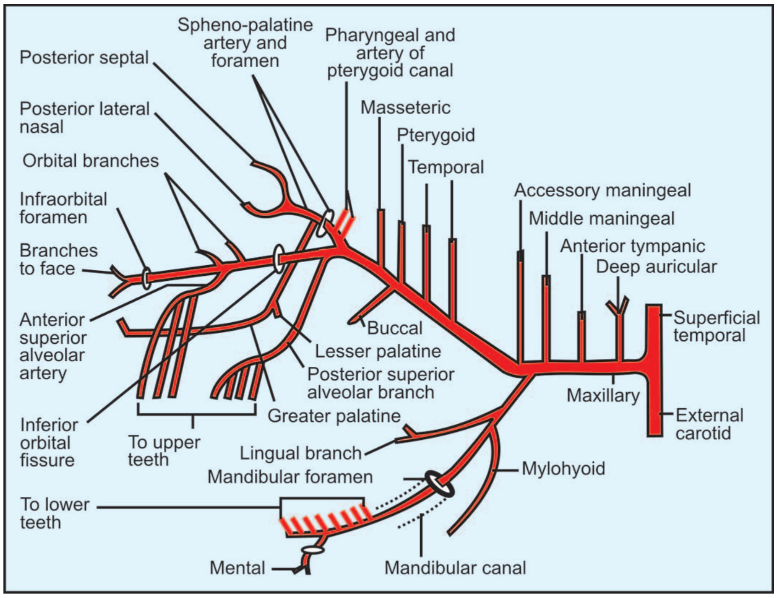
**First part:** First part runs forwards between the neck of the mandible laterally and the sphenomandibular ligament medially. It lies parallel and little below the auriculo-temporal nerve. It runs along the lower border of the lateral pterygoid muscle.

**Second part:** Second part runs forwards and upwards between the lower head of the lateral pterygoid and temporalis. Usually it passes superficial to the lower head of the lateral pterygoid muscle, but may lie deep to it. In such cases it appears for short while between the two heads of the lateral pterygoid in the form of a bold loop (Peeping through two heads).

**Third part:** This part passes in between the two heads of the lateral pterygoid muscle. It enters the pterygo-maxillary fissure and the pterygopalatine fossa. In the pterygo-palatine fossa it lies in front of the pterygopalatine ganglion.

**Branches of First Part are:** They are given to both the jaws, muscles of mastication, nose, palate and the cranial dura.

**Figure 122A** Showing branches of maxillary artery



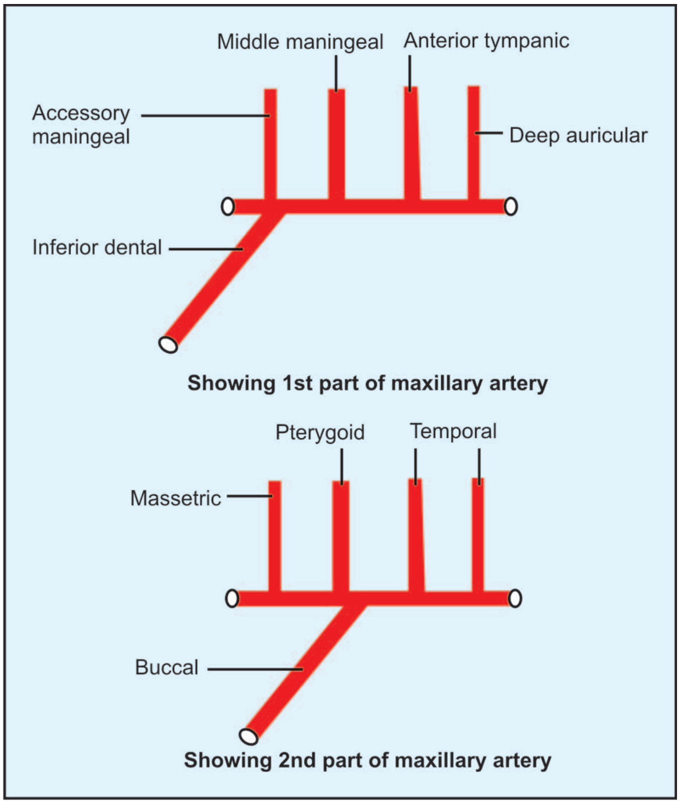



**Figure 122B** Showing 1st and 2nd parts of maxillary artery

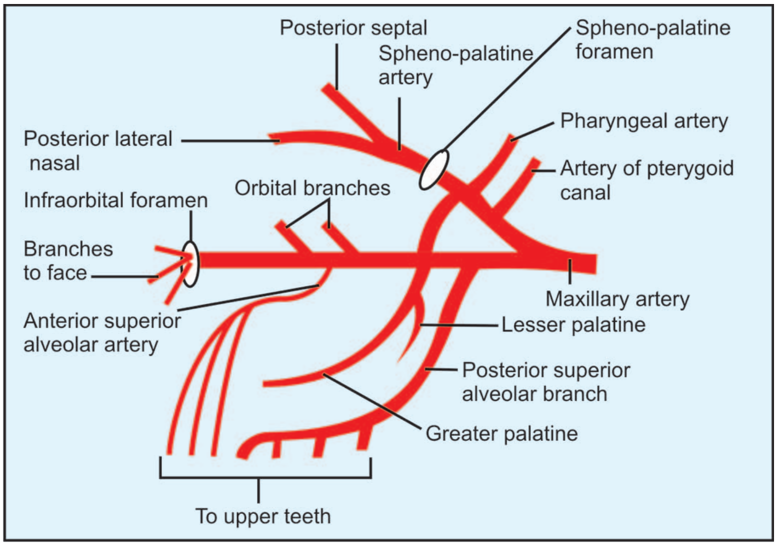



**Figure 122C** Showing 3rd part of maxillary artery

1. Deep auricular
2. Anterior tympanic
3. Inferior alveolar or dental.
4. Middle meningeal.
5. Accessory meningeal.

(Remember the sentence that the Indian Medical Association is Doctors Association)

I – Inferior alveolar or dental.
M – Middle meningeal
A – Accessory meningeal
D – Deep auricular
A – Anterior tympanic.

However the sequence of origin is as under as DAIMA.

1. *Deep auricular:* Often arises in common with the anterior tympanic, and ascends in the substance of the parotid gland and supplies the skin lining and the outer surface of the tympanic membrane. It gives the branch to the temporomandibular joint.
2. *Anterior tympanic artery:* The artery enters the tympanic cavity through petrotympanic fissure and supplies the tympanic membrane. It forms a vascular circle around the tympanic membrane with the posterior tympanic branch of stylomastoid artery.
3. *Middle meningeal artery:* Middle meningeal artery is the largest and most important meningeal branch of the maxillary artery. It ascends between the sphenomandibular ligament and the lateral pterygoid muscle. It is surrounded by the two roots of the auriculotemporal nerve. It enters cranial cavity through the foramen spinosum. In the middle cranial fossa it runs forwards and laterally in the groove on the anterior part of the squamous part of the temporal bone and divides into anterior and posterior branches. Anterior branch is the largest branch. It reaches a groove or a canal at the sphenoidal angle of the parietal bone and divides into branches for the dura mater and the internal surface of the cranium. Some branches run upwards as far as the vertex and others go backwards towards the occipital region. One branch which grooves the parietal bone about 1.5 cm behind the coronal suture corresponds to a line of the pre-central sulcus of the brain. Branches of the middle meningeal artery anastomose with the arteries of the opposite side and with the anterior and the posterior meningeal arteries. Following are the branches of middle meningeal artery in the cranium –
   - A. *Ganglionic:* to trigeminal ganglion and the roots of the trigeminal nerve.
   - B. *Superficial petrosal branch:* enters the hiatus for greater superficial petrosal nerve and gives twigs to the seventh nerve and the tympanic cavity and anastomoses with the stylomastoid branch of the posterior auricular artery.
   - C. *Superior tympanic artery:* Supplies tensor tympani muscle.
   - D. *Temporal branches:* Pass through foramina in the greater wing of the sphenoid and anastomose in the temporal fossa with the deep temporal arteries.
   - E. *Orbital Branch:* Enters through the lateral part of the superior orbital fissure and anastomoses with a recurrent meningeal branch of the lacrimal artery.

**Surface Anatomy (Figure 123):** Middle meningeal artery enters the skull infront of the preauricular point and divides at the point, 2 cm. above the middle of the zygomatic arch. From here anterior branch goes towards the point known as pterion which is 4 cm above and 3.5 cm behind the frontozygomatic suture while the posterior branch goes towards the lambda (occipital region).

**Clinical:** It may get torned in fractures of the temporal region of the skull or even by an injury causing separation of the dura from the bone without fracture causes extradural haematoma which leads to the compression of brain. Area affected is usually the motor region of the cortex. The most prominent symptom is the paralysis of the opposite side of the body. It requires immediate surgical intervention such as trephining, e.g. drilling of the bone at the site and removal of the clot (Haematoma).

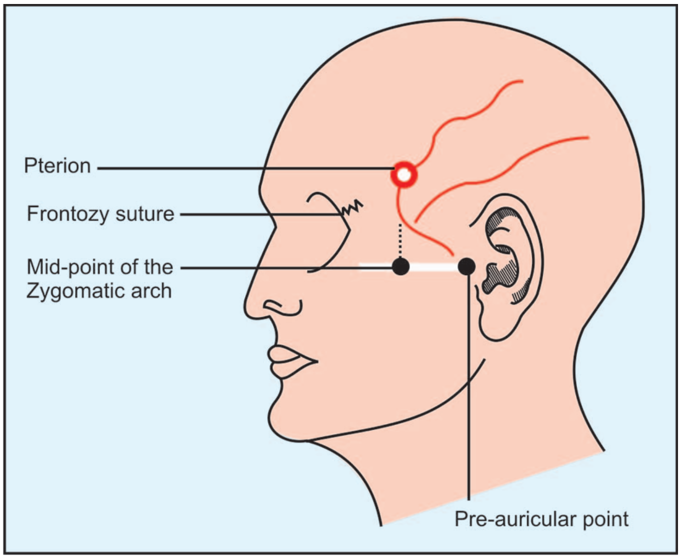



**Figure 123** Showing surface marking of middle meningeal artery

4. *Accessory meningeal artery:* May arise from maxillary or from the middle meningeal. It enters the cranium through the foramen ovale and supplies the trigeminal ganglion and the dura.
5. *Inferior alveolar (Dental) Artery:* Inferior alveolar artery lies behind the inferior alveolar nerve and goes to the mandibular foramen. Here it lies between the bone and the sphenomandibular ligament. Before its entry into the foramen it give the mylohyoid branch, which pierces the sphenomandibular ligament along with the nerve to the mylohyoid. It anastomoses with the submental branch of the facial artery. It runs in the mandibular canal accompanied by the nerve and opposite the first premolar divides into incisor and mental branches. Incisor branch goes forwards and anastomoses with the incisor branch of the opposite side. Inferior alveolar and the incisor give minute branches to the roots of the teeth and supply the pulp. Mental branch appears at the mental foramen and anastomoses there with the submental and the inferior labial arteries. In addition to this, inferior alveolar artery gives the lingual branch near its origin, which is distributed to the mucous membrane of the mouth.

*Branches of the second part (Figure 122B):*
They are all muscular.
1. Deep temporal – to the temporalis.
2. Pterygoid – to the pterygoid muscles.
3. Masseteric – to the masseter muscle.
4. Buccal – to the buccinator muscle.

*Branches of the third part (Figure 122C):*
1. Posterior superior alveolar:
2. Infra-orbital – It gives orbital and antero-superior alveolar.
3. Greater palatine: Passes through greater palatine canal and gives two to three lesser palatine arteries. It emerges on the oral surface of the hard palate through the greater palatine foramen and runs forwards in a groove on the hard palate to the incisive canal. Its terminal branches pass upwards through this canal to anastomose with the branch of the sphenopalatine artery.
4. Pharyngeal branch: It lies medial to the pterygo-palatine ganglion. It runs through the pharyngeal canal with the pharyngeal branch of the

pterygo-palatine ganglion. It is distributed to the roof of the nose and the pharynx, sphenoidal sinus and auditory tube.

5. Artery of the pterygoid canal: It is usually a branch of the greater palatine artery. It passes backwards along the pterygoid canal with the nerve of the pterygoid canal. It is distributed to the upper part of the pharynx, auditory tube and the tympanic cavity.
6. Spheno-palatine artery: (Figure 124) This artery is really a terminal branch of the maxillary artery. It passes through the sphenopalatine foramen into the nasal cavity at the posterior part of the superior meatus of nose. Here it gives posterior nasal branches which are distributed to the conchae, and meatuses. They also assist in supplying frontal, maxillary, ethmoidal and the sphenoidal sinuses, Sphenopalatine artery ends on the nasal septum as posterior septal branches, which anastomose with ethmoidial arteries. One of the branches descends in a groove on the vomer to the incisive canal where it meets the terminal ascending branch of the greater palatine artery.

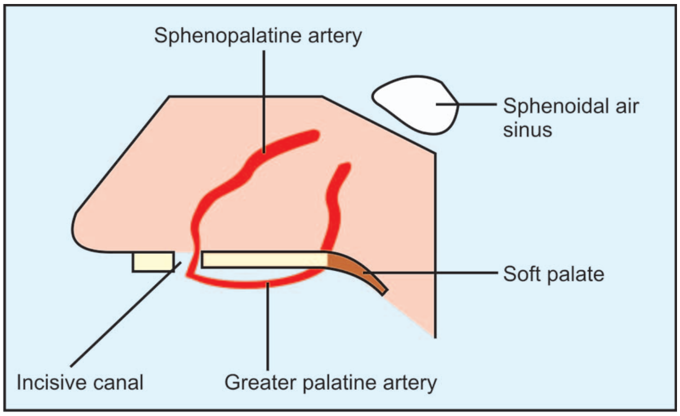



**Figure 124** Showing greater palatine and sphenopalatine arteries

# TEMPOROMANDIBULAR JOINT

**Classification:** Temporomandibular joint is synovial condyloid variety of joint.

**Bones Taking Part:** *Above:* Articular tubercle and the anterior portion of the mandibular fossa of the temporal bone.

*Below:* Head of the mandible which compressed anteroposterior and has tubercles on each side.

**Articular Surfaces (Figure 126):** The articular surfaces are covered with fibrocartilage where the fibers are more predominent than the cartilage cells.

**Articular Disc:** Articular disc is attached to the tubercles of the head of the mandible.

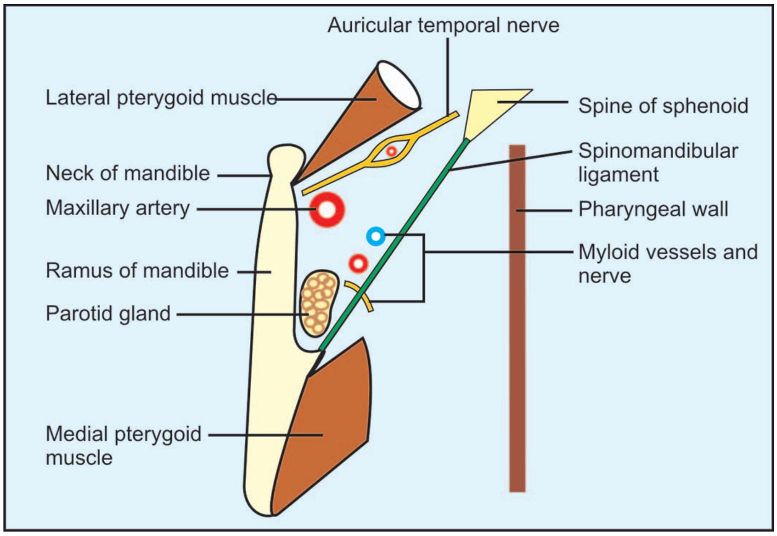



**Figure 125** Showing relations of the sphenomandibular ligament

**Capsule:** Capsule is attached to the articular tubercle in front and the tympano-squamosal fissure behind and to the circumference of the mandibular fossa.

Below it is attached to the neck of the mandible. Above the articular disc, the capsular portion is loose, but below the disc it is tight.

**Ligaments (Figure 126):**

1. **Temporal-mandibular ligament:** Temporal-mandibular ligament is laterally situated. Above it is attached to the tubercle of the root of the zygoma and lower down it is attached to the neck of the mandible. Fibres of this ligament are obliquely placed. It is covered with the parotid gland externally.

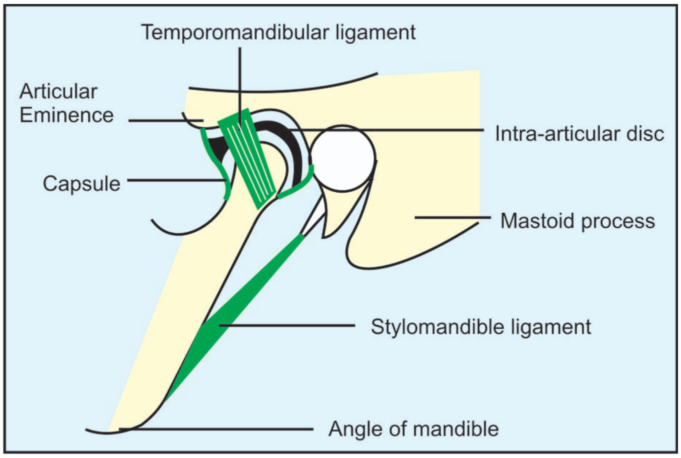



**Figure 126** Showing temporomandibular joint, disc, capsule and stylomandibular ligament

2. **Spheno-mandibular ligament** is on the medial side of the joint. It is flat and thin. It is attached to the spine of the sphenoid above and the lingula of the mandibular foramen below.
3. **Stylomandibular ligament (Figure 126):** Although this is described as a ligament of this joint tip it should only be considered as a supplement. It is attached to the styloid process above and the angle of the mandible below. It is a specialised condensation of the deep cervical fascia.

## Relations of the Sphenomandibular Ligament (Figure 125)

**Lateral Relations:** From above downwards.

1. Lgateral pterygoid.
2. Auriculo-temporal nerve with mandibular nerve and middle meningeal artery.
3. Neck of the mandible and maxillary vessels.
4. Inferior alveolar vessels and nerve and vessel to mylohyoid.
5. Parotid gland.

**Medial Relations:** From above downwards.

1. Chorda tympani.
2. Pharyngeal plexus and pharynx.
3. Medial pterygoid muscle.

**Synovial Membrane:** Synovial membrane lines the fibrous capsule from inside except where the capsule becomes continuous with the peripheral border of the articular disc. Lower down it is reflected over the neck of the mandible and the tendon of the lateral pterygoid muscle to the margin of the articular surface of the head.

**Articular Disc:** Articular disc is oval in shape. It divides the joint cavity into upper and lower compartments. It upper surface is concavoconvex and the lower one is concave. Upper concavoconvex surface is in contact with the articular fossa and the articular tubercle. Lower concave surface is in contact with the head of the mandible. At the periphery, it is connected with the capsule. Anteriorly it is also connected with the tendon of the lateral pterygoid muscle. It must be kept in mind that there are strong, but short horn-like structures which connect the disc to the medial and the lateral poles of the head of the mandible. This fact helps the disc and the head in moving together during the movements of protraction and retraction of the mandible. Posteriorly the disc contains a well marked venous plexus. Because of this the disc shows two lamellae. Upper lamina is made up of fibroelastic tissue and is attached to the posterior margin of the fossa. Lower lamella is made up of white fibrous tissue and is attached to the posterior part of the condyle. Disc is thickest just behind its centre. Some authors have described five zones of the disc. They are arranged antero-posteriorly as under:

1. Anterior extension.
2. Anterior band.
3. Intermediate zone.
4. Posterior band and
5. Bilamillae region.

**Nerves of the Joint:**

1. Auriculo-temporal : Branch of the mandibular
2. Masseteric : Branch of the mandibular

**Blood Supply:**
1. Superficial temporal, and
2. From branch of the maxillary artery (deep auricular)

**Movements:** Following movements take place in this joint:-
1. Depression,
2. Elevation,
3. Protraction,
4. Retraction and side to side movements.

During elevation and depression movements are occurring in both the compartments of the joint (Figure 127).

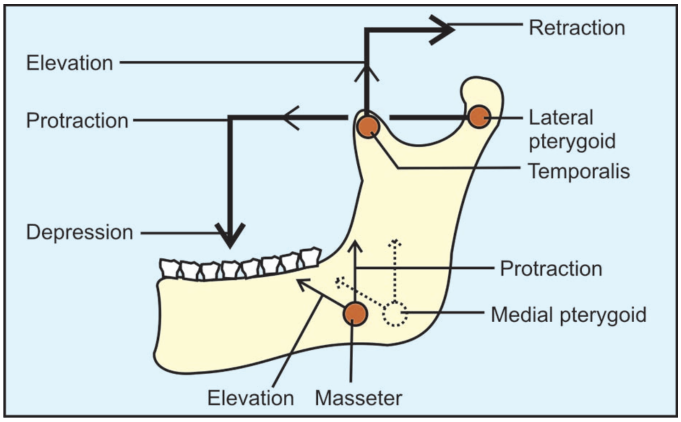



**Figure 127** Showing movements of mandible and the line of pull of muscles of mastication

During depression of the mandible first movement occurs in the upper compartment, when the head of the mandible along with the articular disc moves together. When this movement is exhausted there is a movement in the lower compartment, where the head of the mandible glides forwards under the disc. Exactly the reverse happens during the movement of elevation. During protraction and retraction, movements occur only in the upper compartment. In this case head of the mandible moves forwards along with disc, which is tied to it like a horse saddle.

In lateral movements, head of one side glides with its disc forwards. There is a rotation on its disc along the vertical axis which passes immediately behind the head the opposite side.

It is regarded that the transverse axis around which the movements of elevation and depression take place is situated at the mandibular foramen, where the movements are least. This protects the vessels and nerves, from stretching.

**Muscles producing the movements:**
*Elevator:* Masseter, Temporal (vertical fibres) and medial pterygoid.
*Depressors:* Lateral pterygoid digastric mylohyoid and geniohyoid.
*Protruders:* Medial and lateral pterygoid.
*Retractors:* Temporal is posterior fibres which are placed horizontally.
*Lateral movements:* Medial and lateral pterygoid of both sides acting alternately.

**Clinical:** Commonest dislocation of the head of the mandible is in the forward direction. When mouth is open, head of the mandible is resting against the articular eminence. In this position, sudden downwards blow on the chin or even strong muscular spasm such as in the case of yawing can pull the head of the mandible forwards across the articular eminence into the infratemporal fossa.

The external auditory canal can be injured in acute anterior dislocation of the temporomandibular joint.

**Clicking Jaw:** Detached disc can produce a clicking sound in the joint. It is known as clicking jaw. Chronic recurrent dislocation of the joint is not uncommon, and we have seen patients reducing the dislocation, themselves promptly with no assistance.

**Deeper Contents of Infra-temporal Fossa (Figures 128 and 129):** Following structures lie deep to the lateral pterygoid muscle.

1. Middle meningeal artery.
2. Mandibular nerve and its branches.
3. Chorda-tympani nerve.
4. Otic ganglion.
5. Tensor palati muscle.
6. Pharyngotympanic tube

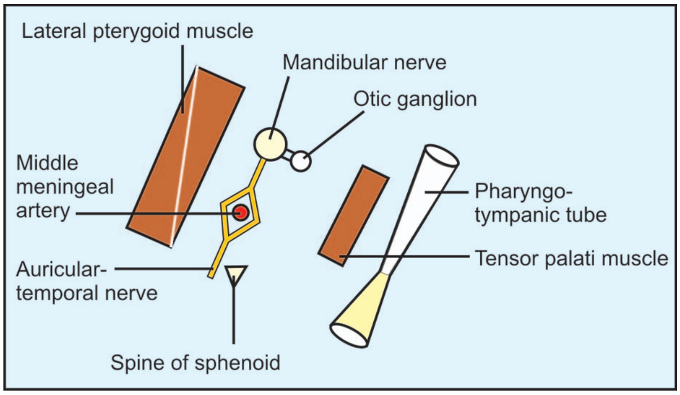



**Figure 128** Showing relations of middle maningeal artery. (also the deep relations of the lateral pterygoid muscle)—highly schematic

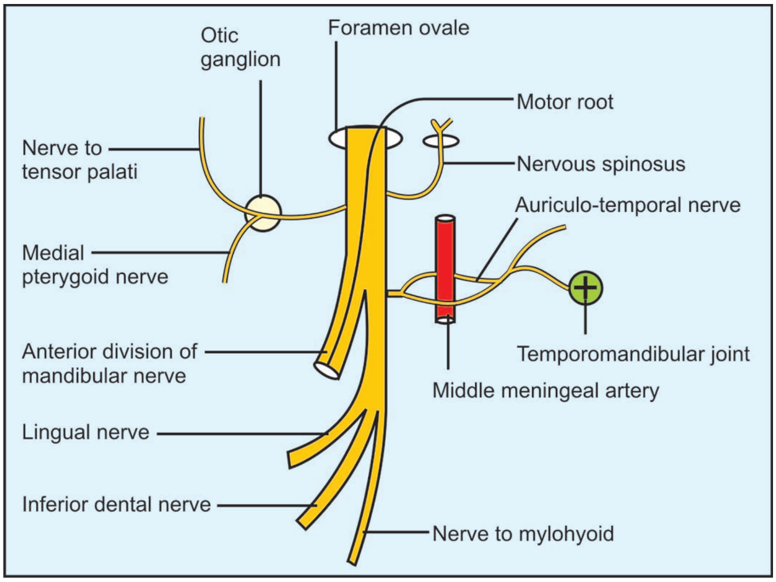



**Figure 129** Showing main branches of the mandibular nerve

**Middle Meningeal Artery:** Middle meningeal artery arises from the first part of the maxillary artery at the lower border of the lateral pterygoid muscle and ascends upwards deep to the muscle. It is surrounded by the two roots of the auriculo-temporal nerve. It enters the middle cranial fossa through the foramen spinosum.

**Relations of the Middle Meningeal Artery:** Middle meningeal artery is closely related to pharynx as it lies lateral to the tensor palate muscle. Tensor palate muscle intervenes between the pharyngotympanic tube and the middle meningeal artery. Artery lies posterolateral to the mandibular nerve.

# MANDIBULAR NERVE

Mandibular nerve arises from the trigeminal ganglion and enters the infra-temporal fossa through the foramen ovale. During its descent through the foramen ovale it is joined by the motor root.

**Branches:** From the trunk:

1. Meningeal.
2. Nerve to medial pterygoid muscle.

The trunk of the nerve divides into anterior and posterior divisions. It is related to lateral pterygoid muscle laterally, medial pterygoid muscle infront, pharynx, medially where tensor palate separates it from the pharyngotympanic tube. Middle meningeal artery lies postero-lateral to the mandibular nerve.

**Anterior Division:** It is mainly motor and immediately gets exhausted by supplying the muscles of mastication. Its sensory element is distributed through the buccal branch.

**Posterior Division:** It gives two roots of the auriculo-temporal nerve and then divides into lingual and inferior alveolar nerve. Motor element of this division is distributed through the mylohyoid branch of the inferior alveolar nerve.

**Meningeal Branch:** Arises from the trunk, enters the cranium through the foramen spinosum and supplies the dura and the middle ear cavity.

**Nerve to Medial Pterygoid:** Otic ganglion is near to its commencement.

**Buccal Nerve:** Passes between the two heads of the lateral pterygoid muscle and reaches the buccinator muscle. It forms a plexus with the buccal branches of the facial nerve. It supplies the skin and the mucous membrane of the cheek. During its course it is intimately related to the surface of the temporalis muscle.

**Nerve to Lateral Pterygoid:** It arises in common with the buccal nerve and enters the muscle.

**Deep Temporal Pterygoid:** Usually they are two, an anterior and the posterior. Deep temporal nerve often arises from the buccal nerve. They supply the temporalis muscle and are in close contact with the temporal bone.

**Nerve to Masseter:** Arises in common with the posterior deep temporal nerve, turns laterally above the lateral pterygoid muscle and passes through the mandibular notch to enter the deep surface of the masseter muscle. It gives few twigs to the temporomandibular joint.

**Auricular-temporal Nerve:** Arises by two roots from the posterior division of the mandibular nerve, surrounds the middle meningeal artery, under cover of the muscle, lateral pterygoid. Both the roots are sensory. Each of them receives a communication from the otic ganglion. Secretomotor fibres to the parotid gland are brought by the auriculotemporal nerve after relay in the otic ganglion. It also supplies the temporomandibular joint.

**Inferior alveolar nerve:** Inferior alveolar nerve is the branch of the posterior division of mandibular nerve. It is larger than the lingual. It runs downwards over the lateral surface of the medial pterygoid muscle and the spheno-mandibular ligament and enters the mandibular foramen. Lingual nerve lies in front of the inferior alveolar branch of the maxillary artery lies behind it. During its course through the mandibular canal it gives branches to the teeth of the lower jaw and appears on the face as a mental nerve through the

mental foramen. Inferior alveolar nerve is purely sensory, but a few motor fibres are present within it, which separate as the mylohyoid nerve. The mylohyoid nerve supplies mylohyoid muscle and the anterior belly of the digastric. It pierces the sphenomandibular ligament along with the mylohyoid vessels.

**Lingual Nerve:** Lingual nerve is sensory, and supplies the mucous membrane of the anterior two-thirds of the tongue. Under the lateral pterygoid muscle it is joined by the chorodatympani nerve. After coming out under the lateral pterygoid muscle it runs downwards and forwards between the medial pterygoid and the mandible to enter the submandibular region. It has no branch in the infratemporal fossa and may have a connection with the inferior alveolar nerve.

**Chorda Tympani:** Chorda tympani is the branch of the facial nerve given in the vertical part of its course. After passing through the middle ear cavity it comes out through the petrotympanic fissure and enters the infratemporal region, grooves the medial side of the spine of the sphenoid and joins the lingual nerve at an acute angle under cover of the lateral pterygoid muscle. It gets fine filament from the otic ganglion.

**Otic Ganglion:** It is a peripheral parasympathetic ganglia associated with mandibular nerve. Otic ganglion is of a size of a head of a pin lying below the base of the skull on the medial side of the trunk of the mandibular nerve, and lateral to the tensor palate muscle. It is on the origin of the nerve to the medial pterygoid muscle.

*It has three roots:*

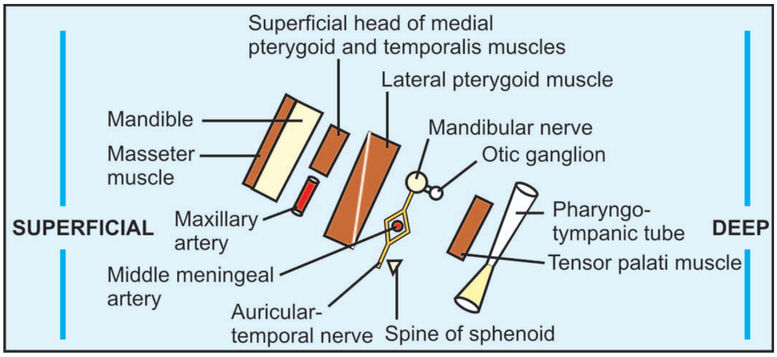
1. Motor-root comes from nerve to medial pterygoid.
2. Sympathetic from middle meningeal artery.
3. Parasympathetic (secretory) through the lesser superficial petrosal.

Following branches proceed from the otic ganglion:

1. To the tensor palati.
2. To the tensor tympani.
3. Filaments to the roots of auricular temporal nerve.
4. Communicating filaments to the chorda tympani and to the nerve of the pterygoid canal.

**Tensor Palati Muscle (Figures 130 and 131):** Tensor palati muscle is under cover of the lateral pterygoid muscle along with the mandibular nerve and middle meningeal artery. It arises from the floor of the scaphoid fossa, medial margin of foramen ovale, base of the spine of sphenoid, and the lateral aspect of the auditory tube. Its tendon grooves the lower surface of the pterygoid hamulus and reaches the soft palate. There is a bursa between the tendon and the hamulus. Tendon of this muscle expands and forms the palatine aponeurosis which is attached to the palatine crest. Palatine aponeurosis is an expanded tendon of the tensor palate muscle.

**Figure 130** Showing relations of tensor palati muscle



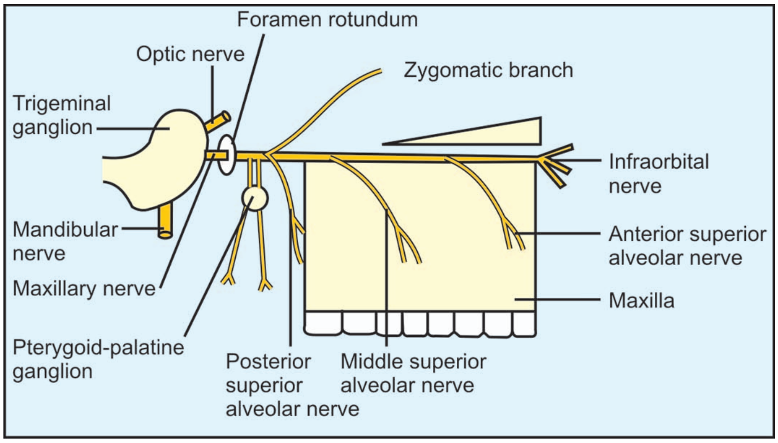



**Figure 131** Showing maxillary nerve pterygo-palatine ganglion

**Nerve Supply:** The tensor palate muscle is supplied by mandibular nerve through the otic ganglion.

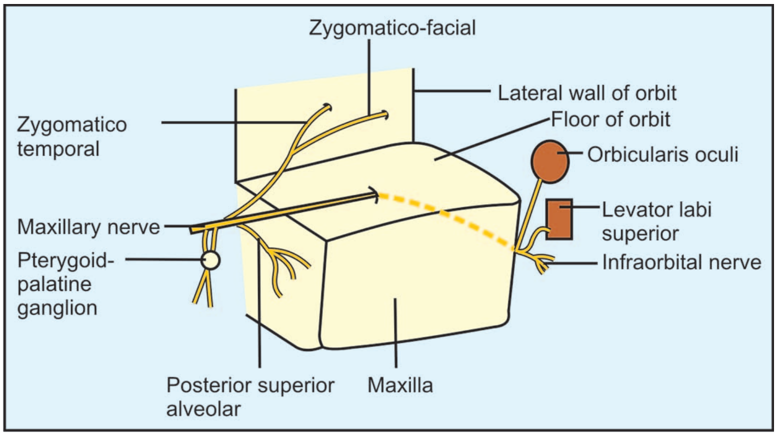
# MAXILLARY NERVE

Maxillary nerve arises from the anterolateral convex surface of the trigeminal ganglion, runs forwards by the side of the body of the sphenoid in between the two layers of the dura mater, by following the lower border of the cavernous sinus. It leaves the cranial cavity through the foramen rotundum and runs through pterygo-palatine fossa. It passes through the inferior orbital fissure to continue as infraorbital nerve.

Following are the branches of the maxillary nerve (Figure 132).

1. Meningeal branch
2. Two ganglionic branches, both of them join the pterygo-palatine ganglion.
3. Anterior superior alveolar and middle superior alveolar.
4. Posterior superior alveolar nerve and the zygomatic nerve.
5. Infraorbital nerve.

**Figure 132** Showing maxillary nerve and its branches




**Posterior Superior Alveolar Nerve:** It divides into two branches, which run on the back of the maxilla. It supplies the mucous membrane of the cheek and the gums. Its dental branches supply the molar and the premolar teeth.

**Posterior Branch:** Posterior branch reaches as far as the canine tooth. Middle superior alveolar nerve is meant for the premolar teeth. The anterior superior alveolar nerve, is for the canine and incisor teeth.

**Zygomatic Nerve:** Zygomatic nerve enters the orbit by passing through the inferior orbital fissure. Here is lies between the lateral wall of the orbit and the orbital periosteum. It divides into two branches, zygomatico-temporal and the zygomatico-facial.

**Infraorbital Nerve:** Infraorbital nerve begins at the middle of the inferior orbital fissure, runs in the infraorbital groove, infraorbital canal and appears on the face at the infraorbital foramen. Infraorbital canal produces a well marked ridge on the roof of the maxillary sinus (This ridge is seen going from the roof to the anterior wall of the maxillary sinus). In the middle of the floor of the orbit it gives a branch known as anterior superior alveolar nerve. The infraorbital nerve is under cover of the levator labii superioris and the orbicularis oculi. It has the labial, the nasal and the palpebral branches. Inflammation of maxillary air sinus gives pain along the infraorbital nerve.

**Maxillary sinus: (Figures 132 to 134) (Antrum of Highmore)** Maxillary sinus is pyramidal in shape, with its base directed medially towards the nasal cavity and the apex is directed laterally at the zygomatic process. It's hiatus on the medial wall is reduced in size by the uncinate process of the ethmoid, the lacrimal bone, maxillary process of the inferior nasal concha and the perpendicular plate of the palatine bone.

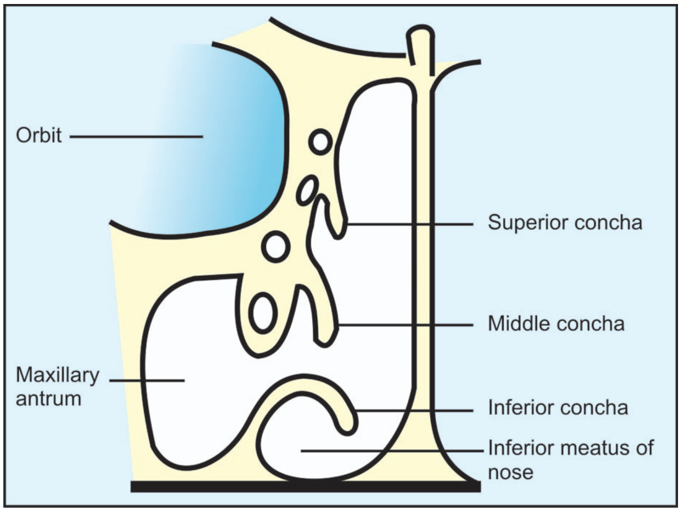



**Figure 133** Showing cross-section of maxillary antrum nasal cavity including orbit

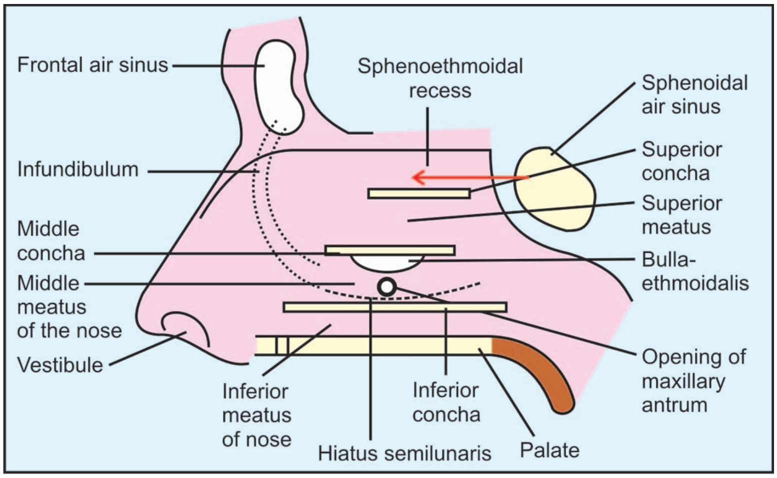



**Figure 134** Showing lateral wall of nose and opening of maxillary air sinus

It is the largest paranasal sinus and is clinically important. It is situated in the body of the maxilla. Above it is related to the orbit, medially to the nasal cavity, posteriorly to the pterygopalatine and the infratemporal fossae lower down to the molar and the premolar teeth. Sometimes an accessory opening is present, which opens in the inferior meatus of the nose and not the middle. It is situated at the lower level near the posterior part of inferior concha. Upper second premolar and molar are closely related to the floor of the sinus.

Deepest part of its floor is opposite the second premolar and first molar. Level of its floor is nearly 1.25 cm below the level of the floor of the nasal cavity. It opens into the hiatus semilunaris of the middle meatus of the nose. Frontal air sinus opens through the hiatus semilunaris through the infundibulum.

Due to the difference in the level of the opening and the floor, secretions get collected in the maxillary sinus instead drainging into the nasal cavity. By virtue of its connections with frontal air sinus secretion of the frontal find it easy to enter the maxillary air sinus. Therefore, the maxillary air

sinus has rightly been described as the secondary reservoir of the frontal air sinus. It is lined by vascular mucous membrane, containing ciliated cells. Movements of the cilia help in drainage of the sinus. When infraorbital canal is deficient inflammation of sinus gives severe pain.

**Clinical:**

1. Inflammation of maxillary air sinus is known as maxillary sinusitis.
2. Antral puncture–In case of collection of infected fluid or pus in the maxillary sinus-antral puncture is done through the inferior meatus of the nose.
3. Carcinoma of maxillar: It arises from the antrum and spreads medially to the nose, above to the floor of the orbit and below to the roof of the oral cavity.
4. Cad well Luc–Operation: Maxillary sinus is approached from the front under the cheek and the lip through the superior alveolus for removal of growth of the antrum. In uncontrolled epitaxis maxillary artery is ligated through transmaxillary approach.

**Structures Seen After the Reflection of Mylohyoid Muscle**

Following structures are seen (Figure 135)

1. Part of the tongue
2. Hyoglossus muscle
3. Styloglossus muscle
4. Genioglossus muscle
5. Geniohyoid muscle
6. Lingual nerve with submandibular salivary ganglion
7. Submandibular salivary gland
8. Hypoglossal nerve
9. Veins
10. Submandibular duct
11. Sublingual gland.

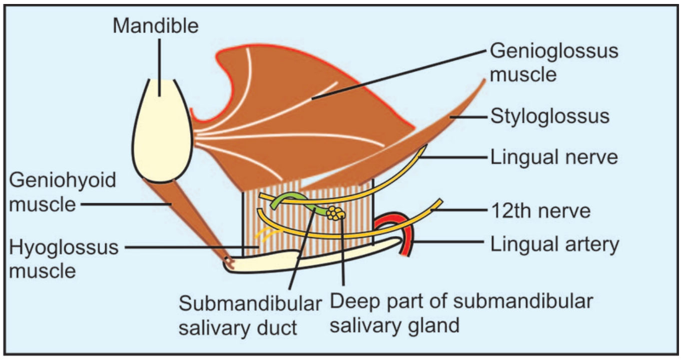



**Figure 135** Showing relations of the hyoglossus muscle

Certain structures are seen passing under cover of the posterior border of the hyoglossus muscle. They are:

1. Glossopharyngeal nerve:
2. Stylohyoid ligament and the
3. Lingual artery.

**Hyoglossus Muscle:** It arises from the body and the greater cornu of the hyoid. Fibres pass upwards for its insertion into the posterior half of the side of the tongue.

**Nerve Supply:** It is supplied by hypoglossal nerve, the twelfth cranial nerve.

**Action :** It depresses the tongue and helps in enlarging the cavity of the mouth in sucking.

**Relations:** Following structures lie on the hyoglossus muscle.

1. Styloglossus muscle.
2. Lingual nerve.
3. Submandibular salivary ganglion.

4. Deep part of the submandibular salivary gland.
5. Hypoglossal nerve
6. Duct of the submandibular salivary gland.
7. Vena comitantes associated hypoglossal nerve.

**Facial Artery (Figures 136 and 137):**

Facial artery arises from the front of the external carotid artery in the carotid triangle above the tip of the greater cornu of the hyoid bone. It has wavy course. It passes vertically upwards under cover of the posterior belly of the digastric, stylohyoid and the angle of the mandible. During this course it lies on the middle and the superior constrictor muscles. It is separated from the tonsil by the superior constrictor muscle. It is related to the posterior end of the submandibular gland, lies between the gland and the medial pterygoid muscle. Finally, it appears at the anteroinferior angle of the masseter muscle, and pierces the deep fascia. Following are the branches of the facial artery in the region of the neck.

**Figure 136** Showing arteries of the face side view

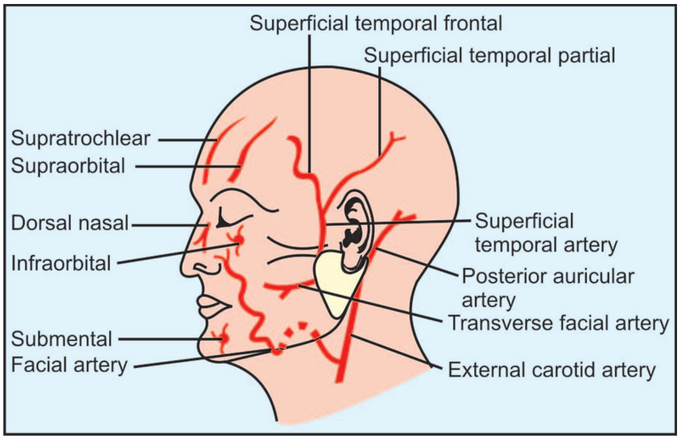
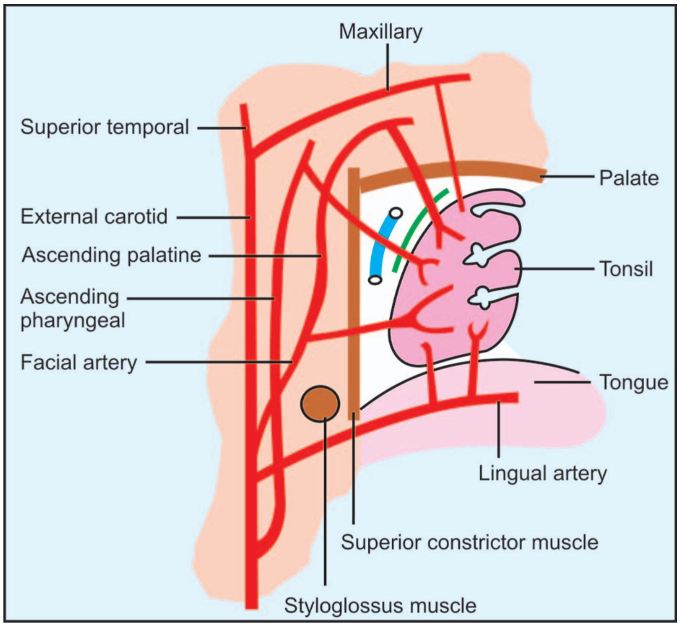



**Figure 137** Showing blood supply of palatine tonsil and its relations to the pharyngeal wall, styloglossus muscle and fascial artery




1. *Ascending palatine:* Ascending palatine artery arises near the origin of the facial. It passes between the styloglossus and stylopharyngeus muscles. Next it goes upward and runs between the superior constrictor muscle medially and the medial pterygoid laterally. It divides into two branches, one of which arches over the super constrictor muscle and follows the levator palate muscle to reach the palate. It anastomoses

with the greater palatine artery. Other branch pierces the superior constrictor muscle, supplies the tonsil and the pharyngotympanic tube. It anastomoses with the tonsillar branch of the facial and the ascending pharyngeal artery.

2. *Tonsillar artery:* It pierces the superior constrictor and enters the tonsil.
3. *Glandular branches:* These are the small twigs given to the submandibular gland.
4. *Submental artery:* It arises from the facial artery near the sub-mandibular salivary gland. It ends by giving number of small branches to mylohyoid muscle, the submandibular and the sublingual salivary gland and the skin around.

**Clinical:**

1. *Ludwig's Angina:* Ludwig's angina begins as the painful swelling beneath the body of the mandible. It is a fulminating streptococcal infection, which begins around the submandibular or the sublingual salivary glands. It rapidly spreads to the sublingual region and the pharynx. Death can occur to the oedema of the glottis. Prompt relief is obtained by free incision through the submandibular swelling, under local anaesthesia. Mylohyoid muscle is divided and the finger is passed through the incision into the sublingual region upto the mucous membrane of the mouth.
2. *Ranula (Figures 138 and 139):* Ranula is the retention cyst of the submandibular or sublingual duct.

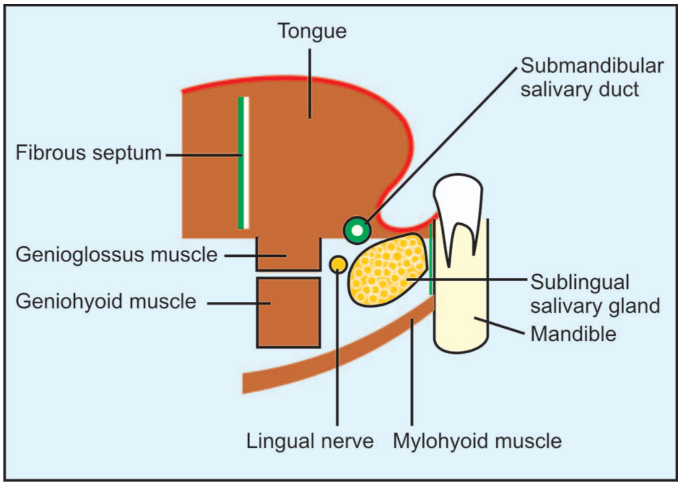



**Figure 138** Showing relations of sublingual salivary gland

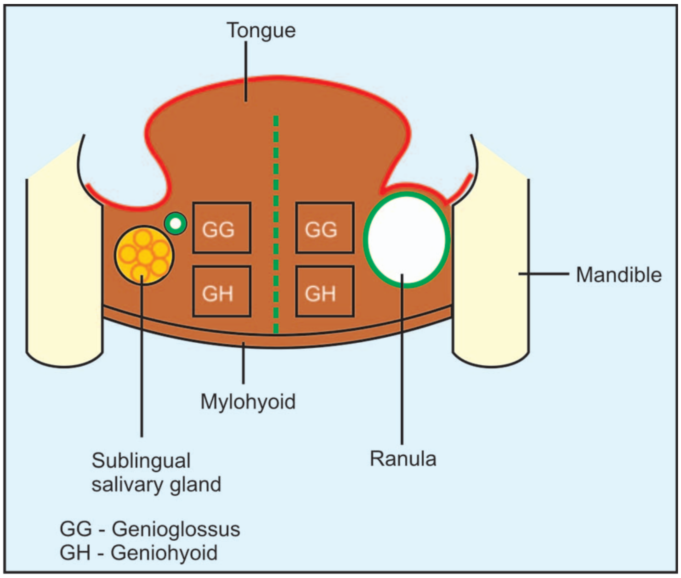



**Figure 139** Showing ranula of left submandibular salivary duct

3. *Calculus in the sublingual gland and ducts:* Can be palpated with the finger placed in the floor of mouth.

Formation of the small calculi in the sublingual salivary gland requires excision (removal) of the gland.

**Styloglossus Muscle:** Styloglossus muscle arises from the tip of the styloid process and from the stylohyoid ligament. It runs downwards, forwards for its insertion into the side of the tongue. Its fibres decussate with the fibres of the hyoglossus muscle.

**Nerve Supply:** Styloglossus muscle is supplied by hypoglossal nerve.

**Action:** Styloglossus muscle pulls the tongue upwards and backwards during the act of swallowing.

**Geniohyoid Muscle:** The geniohyoid muscle is situated nearer the medial plane in contact with the fellow of the opposite side. It arises from the lower genial tubercle of the mandible and runs downwards and backwards for its insertion into the body of the hyoid bone.

**Nerve Supply:** Geniohyoid muscle is supplied by the first cervical nerve through the hypoglossal.

**Action:** Geniohyoid muscle pulls the hyoid bone upwards and forwards.

**Submandibular Duct:** Submandibular duct arises from the medial surface of the gland and runs forwards and upwards towards the floor of the mouth where it opens at the sublingual papilla. The sublingual papilla is an elevation situated at the anterior end of the ridge of mucous membrane known as the sublingual fold. The duct lies on the hyoglossus muscle under the mylohyoid which separates it from the rest of the gland. Above it is related to the lingual nerve which hooks the duct. Lower down it is related to the hypoglossal nerve. During its further course it lies on the genioglossus muscle where it is related to the sublingual salivary gland which separates it from the mylohyoid muscle.

**Sublingual Gland (Figure 140):** It is almond shaped having a length of 3.5 to 4 cm. Superiorly, it is covered with the mucous membrane of floor of the mouth. Medially, it is related to the genioglossus muscle and the submandibular duct and the lingual nerve which lies between it and the muscle. Laterally, it is related to the mandible and the mylohyoid line. Below it is supported by the muscle mylohyoid.

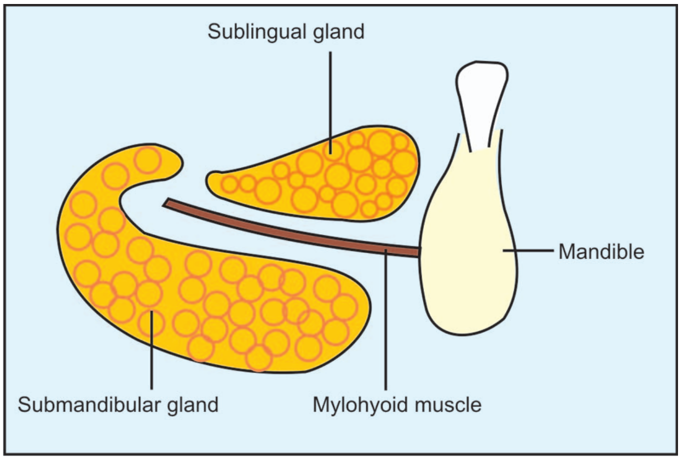



**Figure 140** Showing relation of sublingual and submandibular salivary glands to each other

*Ducts:* There are 10 to 20 ducts which open on the sublingual fold.
*Vessels:* It is supplied by sublingual branch of lingual artery. Submental artery may also supply the gland.

**Nerve Supply:** Comes through lingual nerve. Parasympathetic and sympathetic fibres reach the gland through lingual nerve after relay in the submandibular salivary ganglion.

**Lingual Nerve (Figure 141):** Lingual nerve runs on the medial pterygoid under cover of the ramus of the mandible. As it runs forwards and downwards it lies on the origin of the superior constrictor muscle at the posterior end of the mylohyoid line. At this site it lies below and behind the last molar tooth. It is sandwitched between the mucous membrane of the mouth and the body of the mandible. During extraction of the last molar, the lingular nerve is likely to be damaged here. Lingual nerve immediately leaves the bone and makes contact with the side of the tongue. It crosses the styloglossus, hyoglossus and hooks the submandibular duct.

**Submandibular Salivary Ganglion (Figure 141):** It is peripheral parasympathetic ganglion on the hyoglossus muscle attached to the lingual nerve. It lies above the hypoglossal nerve. *Roots:* It has three roots

1. Sensory from lingual
2. Sympathetic through plexus around the middle meningeal artery from superior cervical ganglion.
3. Parasympathetic or motor through chorda tympani.

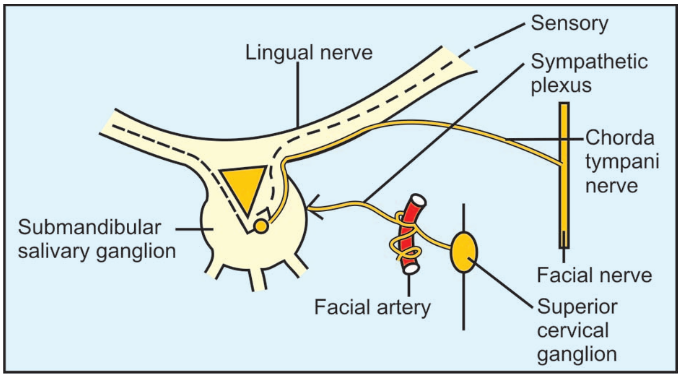



**Figure 141** Showing roots and branches of submandibular salilvary ganglion

**Branches:** Secretomotory fibers supply submandibular and the sublingual glands. General and the special taste sensations from the anterior two-thirds of the tongue except circumvallate papillae are carried by chorda tympani nerve.

**Branches:**

1. *Communicating branches:* They are to the submandibular ganglion and to the hypoglossal nerve.
2. *Branches of distribution:* They are to the anterior two-thirds of the tongue, mucous membrane of the mouth and gums. In addition to this, branches are also given to the sub-lingual gland.

**Hypoglossal Nerve** It runs anteriorly, crossing the loop of the lingual artery at the greater cornu of the hyoid bone and runs forwards on the hyoglossus muscle. On the hyoglossus it is related to the hyoid bone below and the sub-mandibular duct above. At the anterior border of the muscle it is connected to the lingual nerve. Veins from the tongue run in company with nerve on the hypoglossus muscle. Further it runs forwards and goes deep in the substance of the genioglossus muscle. Hypoglossal nerve supplies all the muscle of the tongue both intrinsic and extrinsic except palatoglossus, which being the muscle of palate is supplied by the cranial root of the accessory. Nerve supply of geniohyoid and thyrohyoid come from C1 through the hypoglossal nerve.

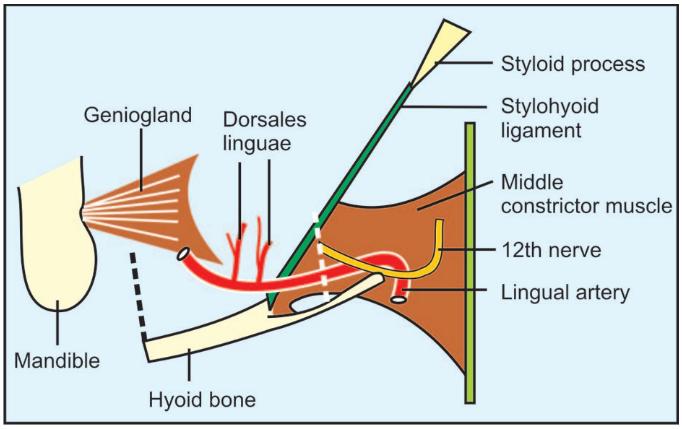



**Figure 142** Showing structures under cover of the hyoglossus

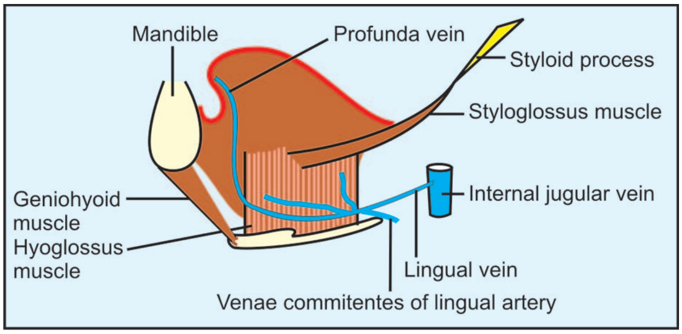



**Figure 143** Showing relations of the hyoglossus muscle with lingual vein

Structures under cover of the hyoglossus (Figures 142 and 143). They are as under:

1. *Muscle:* Part of genioglossus and the origin of middle constrictor.
2. *Vessels:* Lingual artery, dorsales linguae arteries and the veins.
3. *Ligament:* Stylohyoid ligament.

**Genioglossus:** Genioglossus arises from the superior genial tubercle of the mandible and runs in a fan shaped manner backwards for its insertion into the tongue, throughout its whole length, from the base to the tip. Some of the fibres are inserted into the hyoid bone.

**Nerve Supply:** It is supplied by the hypoglossal nerve.

**Action:** It protrudes the tongue when acting together with the fellow of the opposite side.

**Lingual Artery:** It arises from the anterior aspect of the external carotid artery in the carotid triangle a little behind the greater cornu of the hyoid bone. It forms the loop around the greater cornu of the hyoid bone, which is crossed by hypoglossal nerve. Here it is lies on the middle constrictor. It runs under cover of the hypoglossus, follows the anterior border of the hyoglossus muscle and forms the deep artery of the tongue. It is divided into three parts.

**First Part:** It lies in the carotid triangle. Superficially, it is covered with the skin, superficial fascia and the hyoglossal nerve, which crosses the loop of the lingual artery. First part of the lingual artery gives suprahyoid artery. Suprahyoid artery which runs on the hyoglossus muscle, above the upper border of the hyoid bone.

**Second part:** Lies under cover of the hyoglossus muscle. It supplies the mucous membrane of the pharyngeal part of the tongue, and the tonsil. It gives two to three dorsales lingual arteries. This part lies on the middle constrictor muscle and crosses the stylohyoid ligament. It is covered with the hyoglossus, mylohyoid, posterior belly of the digastric and the stylohyoid muscles.

**Third Part:** This part is crossed by all the three structures which lie on the hyoglossus muscle namely the lingual nerve, branches of the hypoglossal nerve and the submandibular duct. Sublingual artery arises from this part and supplies the sublingual gland and the muscle nearby.

**Deep Artery of the Tongue:** Deep artery of the tongue is the continuation of the lingual artery. It enters the tongue about its middle and runs towards the lip. Deep vein of the tongue lies superficial to it. Course of this vessel is wavy like the facial artery. It is because of this fact that the elongation of the tongue is made possible without undue stretch on the vessel.

**Clinical:** Greater cornu of the hyoid bone is an important land for this artery and the posterior belly of the digastric muscle is a guide indicating the depth the surgeon has reached.

**Veins of the Tongue:** Profunda is the chief vein of the tongue. It begins near the tip of the tongue, descends vertically downwards along the anterior border of the hyoglossus muscle. Next it runs on the hyoglossus muscle below the level of the hypoglossal nerve. It units with venae commitantes of the hypoglossal nerve which lie above the nerve, dorsales linguae veins and the venae comitantes of the lingual artery at the posterior border of the hyoglossus muscle to form the lingual vein. Lingual vein either joins the common facial vein or may cross the external and internal carotid arteries to open into the internal jugular vein.

**Stylohyoid Ligament (Figure 144):** Stylohyoid ligament runs from the tip of the styloid process to the lesser cornu of the hyoid bone. This ligament, developmentally, represents the sheath of the second pharyngeal arch cartilage. The styloid process and the lesser cornu of the hyoid bone and the upper half of the body of the hyoid are derived from the second arch.

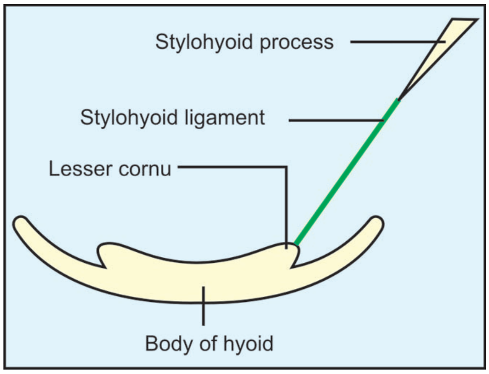



**Figure 144** Showing stylohyoid ligament

# EYELIDS, LACRIMAL APPARATUS AND EXTERNAL NOSE

**Eyelid (Figures 145 and 146):** Eyelid is made up of following structures from before backwards

1. *Skin:* It is very thin.
2. *Superficial fascia:* It does not contain fat. It is because of the loose arrangement of the fascia, effused blood accumulates (Black eye). It can occur due to direct trauma or injury to the lid. In case of injury to the frontal sinus the air in the lid (Emphysema).
3. Orbicularis oculi muscle.
4. *Tarsus, tarsal glands on the deeper surface of the tarsus:* Palpebral fascia and the expanded tendon of the levator palbrae superioris muscle, only in the upper lid.
5. *Conjunctiva:* It is extremely thin and presents as the palpebral parts.

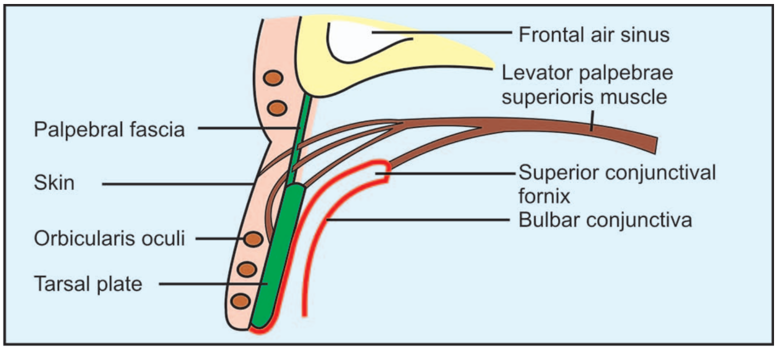



**Figure 145** Showing upper tarsal plate, palpebral fascia and tendon of levator palpebrae superioris muscle with its anterior attachment

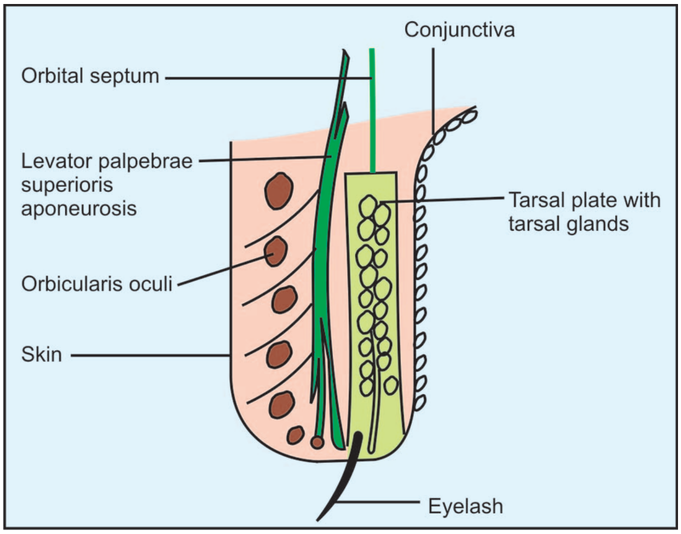



**Figure 146** Showing section of upper lid

**Tarsal Plate of the Lower Lid:** Tarsal plate of the lower lid is narrower than the upper. It is attached to the lower margin of the orbit by means of the palpebral fascia. It is also connected with the medial and the lateral margins of the orbit along with the upper tarsal plate by means of the medial and the lateral palpebral ligaments.

**Tarsal Plate of the Upper Lid:** Tarsal plate of the upper lid is larger than the lower. Its deeper surface is fixed to the conjunctiva. Lower part of its external surface is covered with

the orbicularis oculi muscle. The upper part of the external surface is separated from the muscle by means of palpebral fascia and the tendon of the levator palpebrae superioris.

**Tarsal Glands:** They lie on the deeper surface of the tarsal plates and are arranged in a vertical fashion. Ducts of these glands open at the margin of the lid immediately behind the eye lashes. They are known as, Meibomian glands, Chronic inflammation of these glands is known as Chalazion.

**Ciliary Glands:** They are the minute glands arranged in a row immediately behind the roots of the eye-lashes. Their ducts open at the lid margin near the eye lashes. Inflammation of one of them produces a small red swelling at the lid margin. It is known as stye. They are known as glands of Zeiss (Stye is known as Hordeolum).

**Palpebral Fascia:** Tarsal plates together with palpebral fascia is known as orbital septum. Palpebral fascia fills-up the gap between the tarsal plates and the orbital margins. Although it is attached to the orbital margin all over on the medial side it passes behind the lacrimal sac for its attachment into the posterior border of the fossa for the lacrimal sac. Palpebral fascia of the upper part blends with the expanded tendon of the levator papebrae superioris muscle and gets attached to the anterior surface of the tarsal plate along with it. Vessels and the nerves which come out of the orbit have to pierce it.

**Medial Palpebral Ligament:** Medial palpebral ligament is stronger than the lateral one. It connects two tarsal plates with the medial margin of the orbit. Superficially, it is covered with the skin, and towards its deeper aspect it lies across the lacrimal sac. It gives origin to the fibres of the orbiculari oculi.

**Lateral Palpebral Ligament:** It is a thin fibrous band which connects the two tarsal palates to the lateral margin of the orbit at the small tubercle.

**Levator Palpebrae Superioris:** Some fibres of the tendon after passing through the orbicularis oculi get inserted into the skin of the upper lid. Other filaments are attached to the front and the upper tarsal plate and to the upper conjunctivae fornix.

**Blood Supply of Lid:** Branches of the ophthalmic artery and its lacrimal branches supply the lids. These branches form arches at the margins of the lids.

**Veins Supply of Lid:** They end in the supratrochlear and the supraorbital veins.

**Nerves:** Nerves to the upper lid are:

1. Palpebral branch of the lacrimal
2. Supratrochlear,
3. Supraorbital, and
4. Infratrochlear nerves. All of them are sensory.

Nerves to the lower lid, are derived from the infraorbital nerve.

# LACRIMAL APPARATUS

It comprises the following structures (Figures 147 and 148):

1. Lacrimal gland and its ducts.
2. Conjunctival sac.
3. Lacrimal canaliculi
4. Lacrimal sac
5. Naso-lacrimal duct.
6. Lacrimal fold

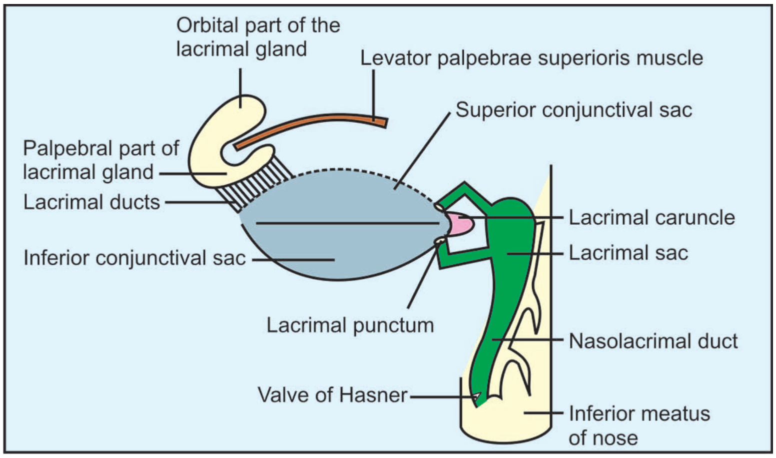



**Figure 147** Showing lacrimal apparatus

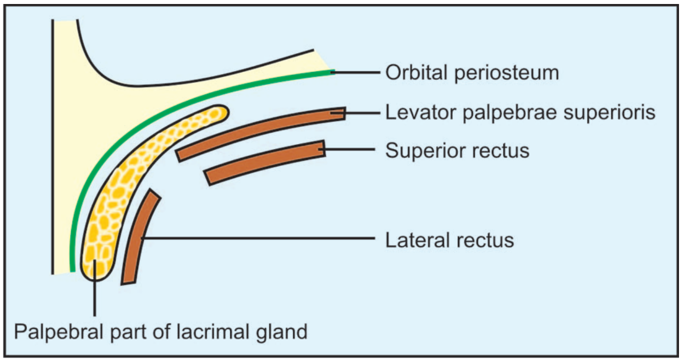



**Figure 148** Showing relations of orbital part of the lacrimal gland

Tears are secreted by the lacrimal gland which lies at the supero-lateral angle of the roof of the orbit. There are about 12 ducts, which bring secretion to the superior conjunctival fornix. All the ducts pass through the palpebral part of the gland. Hence, removal of the palpebral part of the lacrimal gland is functionally equal to the removal of the gland. Even after the excision of the lacrimal gland, conjuctiva does not become dry, due to the accessory lacrimal glands in the conjunctival fornices. Tears are carried from lateral to the medial side by the capillary action and the blinking movements of the eyelids. This transfer of fluid takes place along the groove which lies between the lid margin and the eyeball. As the fluid reaches the locus at the medial angle of the eye it enters the sac due to the contraction of the orbicularis oculi, which tends to turn the openings (puncta) of the lacrimal canaliculi inwards. Capillary action also helps to suck the lacrimal secretion in the sac. It has already been stated that some of the fibres of the orbicularis oculi are attached to the lacrimal sac.

Contraction of these fibres of the orbicularis oculi dilate the sac and helps in the process of lacrimal circulation. Normally the secretions of the tarsal glands prevents the tears from overflowing the lid margins and prevents its evaporation due to its oily nature.

**Lacrimal Gland: (Figures 147 and 148)**

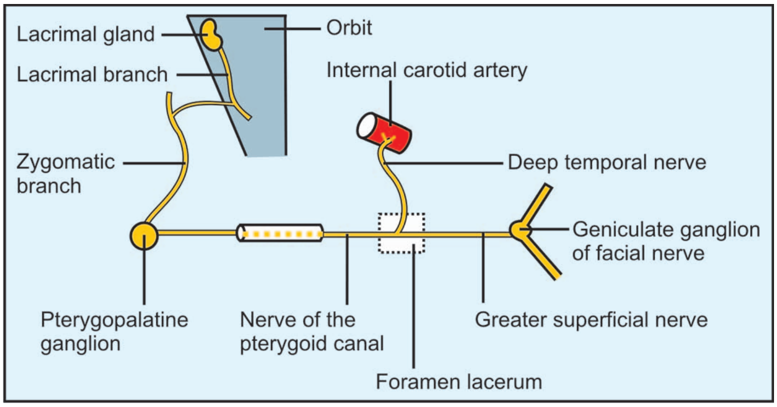
It consists of the two parts, namely the orbital and the palpebral. They are continuous with each other at the lateral edge of the levator palpebrae superioris muscle. Orbital part is of a size of an almond and is lodged in the lacrimal fossa of the zygomatic process of the frontal bone. The gland lies at the anterolateral corner of the roof of the orbit. It lies on the levator palpebrae superioris and the lateral rectus muscles. Its anterior border is related to the orbital septum and its posterior border is in contact with orbital fat. The palpebral part is smaller, about one-third of the orbital part. It is situated below the tendon of the levator palpebrae superioris muscle in the lateral part of the upper lid. Palpebral part of the lacrimal gland presents two to three lobules under the levator palpebral superiaris and is attached to the superior conjunctival fornix. Palpebral part of the lacrimal gland can be seen under the conjunctiva by evertion of the upper lid. Accessory lacrimal glands are small glands under subconjuntival layer behind the tarsal plate.

**Nerve Supply (Figure 149):**

Nerve supply of the lacrimal gland is from the special lacrimatory nucleus in the lower part of the pons. As the nervous intermedius it joins the geniculate ganglion of the facial nerve. Fibres leave the geniculate ganglion in the form of the greater petrosal superficial nerve joins the deep petrosal nerve which is formed by the sympathetic plexus around the internal carotid artery, in the foramen lacerum. Union of the greater superficial petrosal with the deep petrosal forms the nerve of the pterygoid canal.

Nerve of the pterygoid canal carries secretomotor fibres to the lacrimal gland, after relay in the pterygopalatine ganglia through the zygomatico-temporal and the lacrimal nerves.

**Figure 149** Showing secretomotor supply of lacrimal gland




**Development:**

Lacrimal gland and the sac are ectodermal in origin. Lacrimal gland arises at 25 mm stage as number of small solid epithelial buds from the upper and outer part of the conjuctival sac. Lacrimal canaliculi appear as solid buds. Two canaliculi grow medially and fuse with a solid epithelial cord. The cord becomes canalised to form the lacrimal sac and the nasolacrimal duct. Its opening in the inferior meatus of the nose is provided with a valve (valve of Hasner).

**Conjunctiva:**

It is a membrane having epithelial covering. It lines the deep surface of the lid and gets reflected over the sclera of the eyeball forming the conjunctival fornix. Conjunctival sac has a capillary interval between the palpebral

and the ocular conjunctivae. Palpebral and bulbar conjunctivae can get fused due to chronic irritation or infection like trachoma (Symblepharon).

**Lacrimal Canaliculi:** Two slender tubes, having a length of about 10 mm long, open into the lacrimal sac. Superior canaliculus is shorter in length, it has an ascending and the inferomedial parts which meets the lacrimal sac. Infererior canaliculus has descending and horizontal parts. Each canacliculus has an angle presenting an ampula. Lining of the canaliculus is formed by non-karatinised stratified squamous epithelium. The canalicular walls are rich in elastic tissue therefore easily dialatable with a probe. Contraction of the orbicularis oris muscle keeps the punctia of the canaliculi in contact with the conjunctiva.

**Structure of the Lacrimal Gland:** The gland is compound–tubulo alveolar type. Each acinus has a well defined basement membrane having columnar cells. Histological picture of the columnar cell is typical because of the presence of secretary granules and fat droplets. The secretion contains salts and an enzyme (lysozyme), which is lethal to the bacteria.

**Lacrimal Sac:** It has a fibroelastic wall and has the length of 12 mm. It is situated in the lacrimal groove at the medial wall of the orbit behind the medial palpebral ligament. Its upper end is blind and the lower is continuous with the nasolacrimal duct. It looks as if divided in two parts by the medial palpebral ligament. Lacrimal fascia is continuous with the orbital periosteum and forms the roof of the lateral wall of the lacrimal fossa. Fascia lies between the sac and medial palpebral ligament anteriorly and between the sac and the orbicularis oculi and the sac posteriorly.

**Mucocele of the Lacrimal Sac:** It occurs due to blockage of the nasolacrimal duct. Swelling appears at the medial angle of the eye which has a constriction in the middle caused by the medial palpebral ligament which lies anterior. Infected mucocele becomes painful and is known as acute dacrocystitis. It can be treated by bypass operation known as dacryocystorhinostomy (DCR).

**Mikulicz's Disease:** John Von Mikulicz's, a Polish surgeon described this syndrome in 1892. It consists of three presenting signs.

1. E – enlargement of all the salivary glands (symmetrical)
2. N – narrowing of the palpebral fissure due to enlargement of the lacrimal gland.
3. D – dryness of the mouth and the eyes.

The triad of the Mikulicz's disease can be described by the word 'END', indicating enlargement, Narrowing and the Dryness.

**Nasolacrimal Duct:** Nasolacrimal duct is 18 mm long. It runs downwards, backwards and laterally to open into the inferior meatus of the nose. It is narrow in the middle. At its medial end is the lacrimal fold which functions as a flap-valve. (Valve of Hasner). The duct is lined by columnar ciliated epithelium at places.

**Lacrimal Fluid:** Normally, most of the fluid is evaporated, and the remaining is carried by the lacrimal canaliculi to the sac. It goes to the inferior meatus of the nose, through the nasolacrimal duct. In case of excessive production of secretion, tears overflow the medial angle of the eye (Epiphora). Oily secretion of the tarsal glands form the film over the cornea and the conjunctiva which delays in evaporation of the fluid.

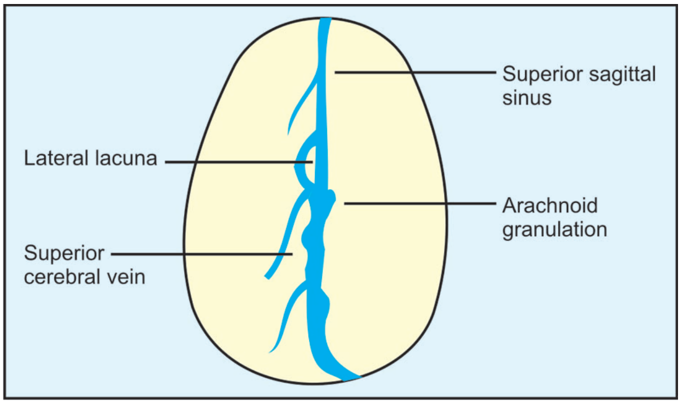
**Clinical:** Block in the nasolacrimal duct or congenital defect in the mucous fold (Valve of Hasner) at the opening in the inferior meatus of nose can cause epiphora, i.e. excessive running of tears. Inflammation of the sac is known as dacrocystitis. It can be treated by (dacrocystorrhinostomy). Medial extension of the carcinoma of the maxilla can present with epiphora due to compression of the nasolacrimal duct by the tumor.

# CRANIAL CAVITY

**Dura Mater of the Brain:** Brain has three membranes: the pia, arachnoid, and the dura from inside out. Dura mater is firmly attached to the sutural ligaments and the base of the cranium. This explains the reason of dural tear in fractures of the base of skull. It is loosely attached to the vault of skull. In children the dura is firmly attached to the skull. The attachment to the base of skull is aided by dural sheaths of cranial nerves. They act as living nails fixing the dura to the base of the skull. Number of small grooves are seen on the inner side of the skull. They are not produced by the meningeal arteries, but by the veins which are more superficially placed. Meningeal arteries supply the dura mater, the inner table of the vault of the skull and the diploe. Outer surface of the skull is supplied by the arteries of the muscles attached to the skull.

**Archnoid Granulations (Figure 150):** These are the normal enlargements of the archnoid villi. They are described as the macroscopic projections of the arachnoid into the superior sagittal sinus. They are more along the posterior part of the superior sagittal sinus. They can be seen at other places like the middle meningeal veins. They have tendency to increase in size get calcified with the advancement of age, and produce impressions by the side of the groove for the superior sagittal sinus. Arachnoid granulations have microvilli through which CSF is pushed into the superior sagittal sinus.

**Figure 150** Showing superior sagittal sinus and the veins nearby




Functions of the dura mater of the cranium:

1. It acts as an endostium of the skull bones and
2. The dura protects and supports different parts of the brain. It has two layers, the outer and the inner. In between the two layers are the intracranial venous channels called as the intracranial venous sinuses. Inner layer of the dura forms strong partitions, which divides the cranial cavity into compartments by the vertical cresentric fold the falx cerebri and the horizontal tent like tentorium cerebelli. Falx cerebri divides the cranial cavity into the right and the left, while the horizontally placed tentorium cerebelli divide the cavity into the supratentorial and the introtentorial compartments, i.e. superior and the inferior (Figure 151).

**Subdural Space:** It is a potential space in between the dura and the arachnoid mater. External surface of the dura is rough while its internal is smooth.

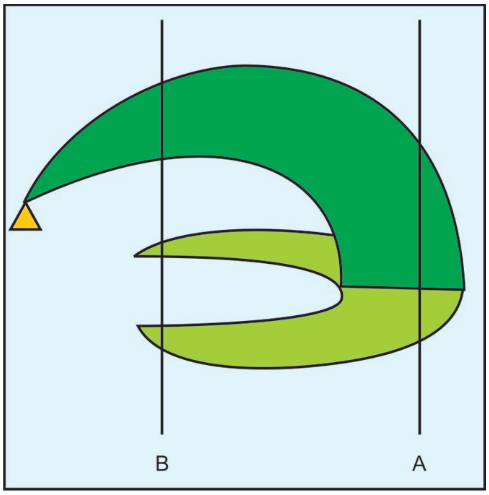



**Figure 151** Showing relations of the falx cerebri and the tentorium cerebelli

**Clinical (Figure 152):** Chronic subdural hematoma occurs due to the rupture of veins running from the cortical surface of the brain to the superior sagittal sinus. It is as a result of displacement of the brain due to blow on the head. Forceful cough and powerful sneeze can also lead to the formation of the subdural hematoma. Subdural hematoma needs surgical removal.

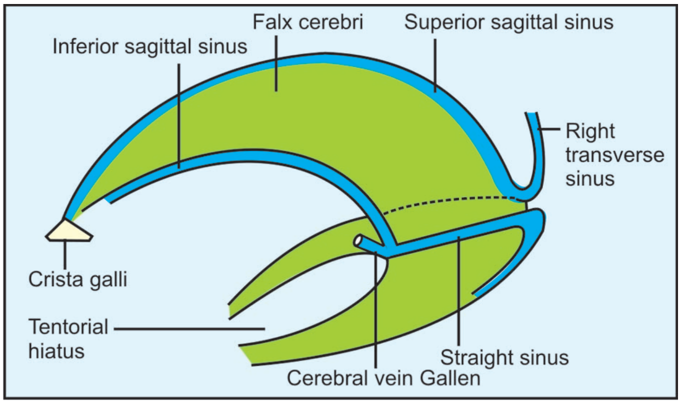



**Figure 152** Showing falx cerebri and tentorium cerebelli with superior, inferior sagittal sinuses and formation of straight sinus by union of inferior sagittal sinus and great cerebral vein of Gallen. Note superior sagittal sinus continues as right transverse sinus

**Epidural Space:** The inner layer of cranial dura passes through the foramen magnum to continues as the spinal dura. The infection of the epidural space of the vertebral canal cannot reach to cranium as there is no epidural space in the cranium.

**Superior Cerebral Veins:** They run upwards towards the median plane. As they reach the superior sagittal sinus they turn forwards, along the side of the superior sagittal sinus for the while and before opening into the sinus.

**Clinical:** Rupture of the superior cerebral veins causes subdural haematoma.

**Venous Sinuses of the Dura Mater (see Figures 151 and 152):** They are the intracranial venous channels situated between the two layers of the dura and are lined by endothelium. They are devoid of valves and the muscular walls hence non-compressible.

They are divided into two groups

1. Posterosuperior group.
2. Anteroinferior group.

Following sinuses come under the posterosuperior group:

A. Superior sagittal sinus.
B. Inferior sagittal sinus.
C. Straight sinus.
D. Two transverse sinuses.

E. Two sigmoid sinuses.
F. Occipital sinus.

Following sinuses come under the anteroinferior group:

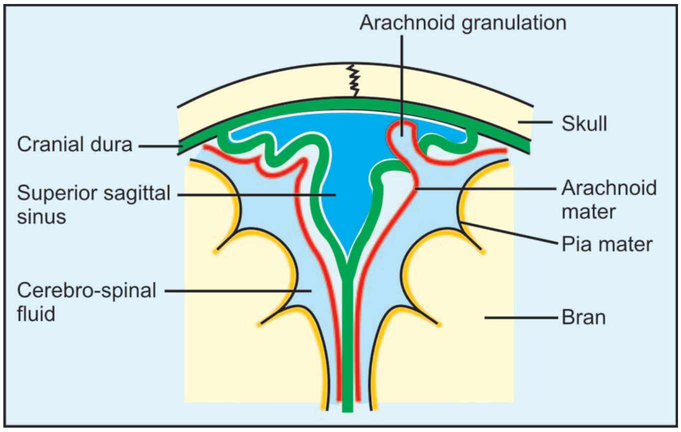
A. Cavernous sinuses.
B. Sphenoparietal sinuses.
C. Intercavernous sinuses.
D. Superior petrosal sinuses.
E. Inferior petrosal sinuses.
F. Basilar sinus.
G. Middle meningeal – sinuses

The sinuses can be classified into the paired and the unpaired groups.

| *Paired* | *Unpaired* |
|---|---|
| 1. Sphenoparietal sinuses | 1. Superior sagittal sinus |
| 2. Cavernous sinuses | 2. Inferior sagittal sinus |
| 3. Middle meningeal sinuses | 3. Intercavernous sinuses |
| 4. Superior petrosal sinuses | 4. Straight sinus |
| 5. Interior petrosal sinuses | 5. Basilar sinus |
| 6. Transverse sinuses | 6. Occipital sinus |
| 7. Sigmoid sinuses | |

**Superior Sagittal Ssinus (Figure 153):** It must be remembered that it lies little to the right of the midplane. It is in the attached convex margin of the falx cerebri. It is triangular in section and gradually increases in size as it passes backwards. It begins in front of the crista galli and runs backwards, grooving the inner surface of the frontal bone, adjoining parts of the parietal bones and the squamous part of the occipital bone. It reaches the internal occipital protuberance where it turns to the right and continues as the transverse and sigmoid sinuses. Openings of the superior cerebral veins and the archnoid granulations are deeply projecting inside the sinus. It also communicates with the venous lacunas which are three in number on either side. Sometimes, these lacunae become continuous to form a large single lacuna. Anteriorly it receives a small vein from the nasal cavity when the foramen caecum is patent (caecum means blind). Superior sagittal sinus receives superior cerebral veins and near the posterior end, veins from the pericranium which pass through the emissary parietal foramina. Venous lacunae receive the diploic and the meningeal veins. The superior cerebral veins do not open into the lacunae but pass beneath them to open into the superior sagittal sinus. Their terminal course is directed anteriorly.

**Figure 153** Showing coronal section of superior sagittal sinus



**Confluence of the Sinuses:** Confluence of the sinuses is the dilated posterior end of the superior sagittal sinus. It is situated on the (right) of the internal occipital protuberance, where four sinuses meet.

**Clinical:** As the superior sagittal sinus communicates with the veins of the nose, scalp and the diploe, infective process in any of them can leads to thrombosis of the superior sagittal sinus. As the superior sagittal sinus itself continues as the right transverse and the right sigmoid sinuses their bony grooves are larger on the right.

**Falx Cerebri:** Inner layer of the dura mater gets duplicated in the form of a crecentic shaped fold and descends between the two cerebral hemispheres. Anteriorly it is attached to the crista galli, runs backwards and gets attached to the superior aspect of the tentorium cerebelli, which forms the roof of the posterior cranial fossa. Its convex margin is directed upwards and is attached to the lips of the groove for the superior sagittal sinus. It encloses the superior sagittal sinus while its lower border is free concave and encloses the inferior sagittal sinus. Lower border of its posterior aspect where it is attached the tentorium cerebelli encloses the straight sinus. The posterior part of the free inferior border comes in contact with the corpus callosum, the body of greatest commisoral fibres (Figures 154 and 155).

**Figure 154** Showing coronal section at line B

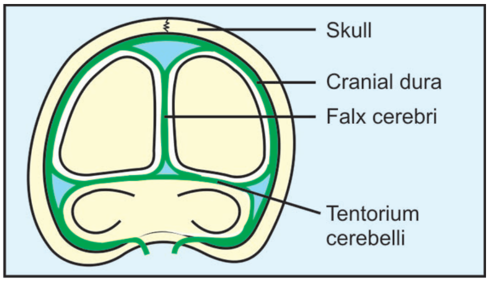
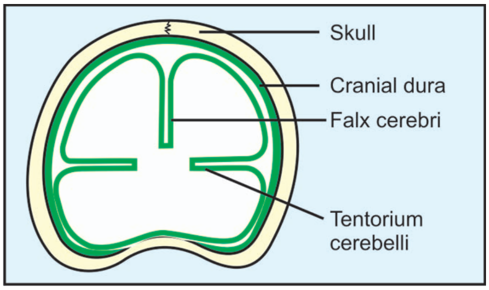



**Figure 155** Showing coronal section at line A




**Parts seen after Removal of Cerebrum:** Cranial cavity is divided into three fossae, anterior, middle and the posterior. Posterior cranial fossa is occupied by the cerebellum which is covered with the double layer dura known as the tentorium cerebelli. Tentorium cerebelli is attached at the periphery to the lips of the groove for the transverse sinus, superior border of the petrous part of the temporal bone and the posterior clinoid process. Free margin forms the opening in the middle of the tentorium, which is attached to the anterior clinoid processes. The fixed and the free margins cross. The opening in the tentorium is occupied by the cut portion of the mid-brain. Basilar artery is seen in front of the mid-brain dividing into the posterior cerebral arteries. From the front of the mid-brain, oculomotor nerves run forwards and laterally. It pierces the arachnoid of the triangular interval between the free and fixed margins of the tentorium cerebellum. On the lateral side of the mid-brain trochlear nerves run anteriorly. Trochlear nerve perforates the inner layer of dura below the free margin of the tentorium cerebelli

behind the posterior clinoid process. On the posterolateral aspect of the mid-brain, basal veins are seen posteromedially to join the great cerebral vein, (of Gllen). Attached to the anterior and posterior clinoid processes is the dural cover of the fossa for the pituitary gland. It is pierced in the centre by the infundibulum of the pituitary gland. Situated on either side of the body of the sphenoid are two box like paired venous sinuses known as the cavernous sinuses. Oculomotor and the trochlear nerves after piercing the dura pass through the lateral wall of the cavernous sinus. Lying immediately postero-lateral to the lateral wall of the cavernous sinus is the trigeminal ganglion. It is situated at the apex of the petrous part of the temporal bone in a special dural sheath known as cavum trigeminale. Still lateral to it are the middle meningeal arteries and its branches and the greater and lesser superficial petrosal nerve over the anterolateral surface of the petrous part of the temporal bone.

Medial to the anterior clinoid process is the optic foramen on either side. It is occupied by the ophthalmic artery and the optic nerve. Internal carotid artery is medial to the anterior clinoid process. The anterior cranial fossa presents a crest in the median plane anteriorly, known as crista galli. It gives attachment to the falx cerebri. On either side of the crista are the cribriform plates of the ethmoid bone. Olfactory nerves leave the nasal cavity through the openings in cribriform plate and join the olfactory bulb. Olfactory bulb lies on the lateral edge of the cribriform plate on either side. The surface of the anterior cranial fossa is related to the orbital surface of the frontal lobe. Fine grooves produced by the branches of the middle meningeal vessels are also seen. Lesser wing of the sphenoid forms the posterior limit of the anterior cranial fossa. Along its free margin lies the sinus, known as the spheno-parietal sinus. Posterior margin of lesser wing ends medially into the anterior clinoid process. It fits in to the stem of the lateral sulcus of the cerebrum.

In the region of the posterior cranial fossa, the superior sagittal sinus turns to the right at the internal occipital protuberance to continue as the right transverse sinus. Straight sinus which lies along the line of attachment of the tentorium cerebelli and the falx cerebri, turns to the left to continue as the left transverse sinus. Transverse sinus, at the base of the petrous part of the temporal bone leaves the tentorium and runs downwards as the sigmoid sinus. Transverse sinus near its end is connected to the cavernous sinus by means of the superior petrosal sinus which lies along the superior border of the petrous part of the temporal bone. Anterior and posterior inter-cavernous sinuses are in the anterior and the posterior borders of the diaphragma sellae.

At the free margin of the tentorium cerebelli; superior and the inferior layers are continuous with each other. The evagination of the inferior layer of the tentorium into the middle cranial fossa forms the cavum trigeminale.

**Inferior Sagittal Sinus:** It lies in the posterior two-thirds of the free border of the falx cerebri. It joins the great cerebral vein (of Galen) at the point where the falx cerebri joins tentorium, to form the straight sinus.

**Tributaries:** It receives small veins from the falx cerebri and also from the middle third of the medial surface of the cerebral hemispheres.

**Straight Sinus:** It is formed by union of the inferior sagittal sinus and the great cerebral vein. It runs along the line of attachment of the falx cerebri to the tentorium cerebelli. It turns to the left to continue as left transverse sinus.

**Tributaries:** It receives small veins from the falx, from the posterior part of the cerebrum and the cerebellum. Superior sagittal sinus, straight sinus and two transverse sinuses meet at a common dialation known as the confluence of the sinuses.

**Transverse Sinus (Figures 156 and 156A):** Transverse sinus begins at the internal occipital protuberance, runs laterally horizontally, and forwards. It lies in the groove for the transverse sinus on the cranial surface of the occipital bone and is bounded by outer layer of the dura of cranium and the two layers of the tentorium. The right sinus is the continuation of the superior sagittal sinus and the left is the continuation of the straight sinus. It ends at the base of the petrous part of the temporal bone to continue as the sigmoid sinus.

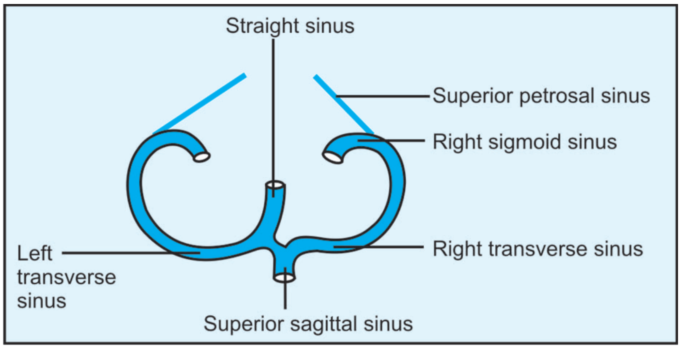



**Figure 156** Showing formation of intracranial verucous sinuses

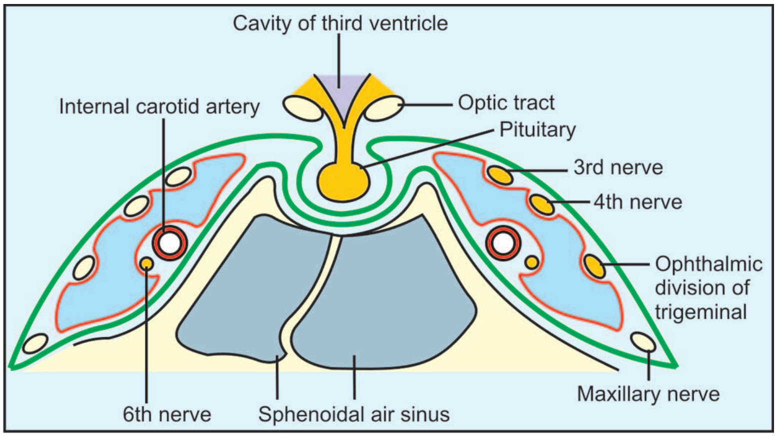



**Figure 156A** Showing relations of cavernous sinus in coronal section of middle cranial fossa

**Relations:** Superiorly, it is related to the cerebrum and inferiorly related to cerebellum. Externally it is related to superior nuchal line and the posteroinferior angle of the parietal bone which is grooved by it.

**Tributaries :** It receives following veins:

1. Occipital diploic veins.
2. Superior petrosal sinus.
3. Veins from the cerebrum and the cerebellum.

**Superior Petrosal Sinus:** Superior petrosal sinus connects the posterior end of the cavernous sinus with the transverse sinus. It run along the superior border of the petrous temporal bone between the attached margin of the tentorium cerebelli. It receives cerebellar veins, inferior cerebral veins and the veins from the tympanic cavity.

**Cavernus Sinus:** They are the box like paired intracranial venous sinuses situated in the middle cranial fossa by the side of the body of the sphenoid. Cavernous sinuses are clinically important due to its relations and the connections in the event of infection.

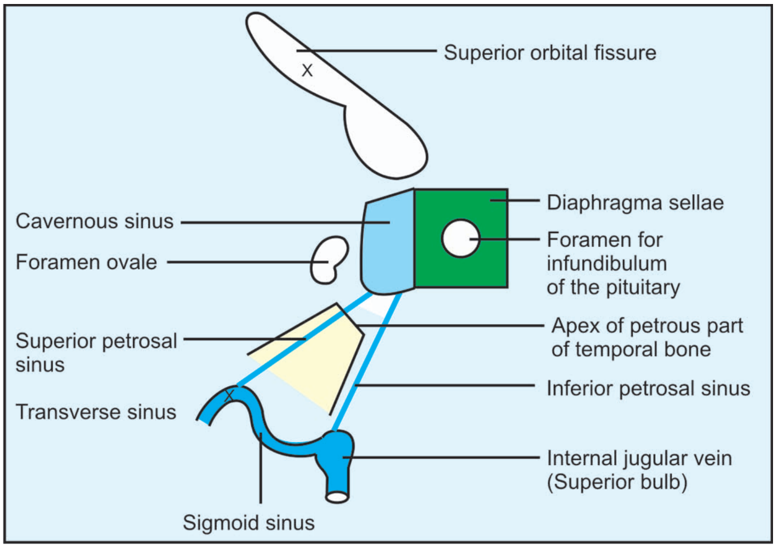
**Formation:** It is formed by separation of the two layers of the dura of the middle cranial fossa. It is lined by the endothelium and its cavity is transversed by the delicate fibrous strands which give cavernous appears (cavernous means a large gloomy cave).

**Extent:** It lies on either side of the body of the sphenoid and its anterior end reaches the medial end of the superior orbital fissure and the posterior touches the apex of the petrous temporal bone.

**Measurements:** It is two centimeter long and one centimeter wide.

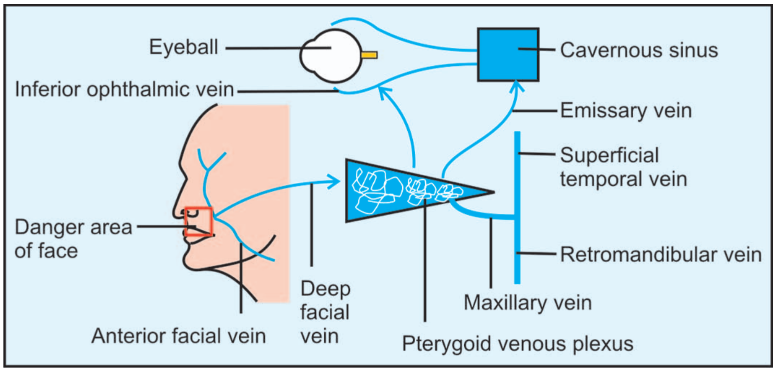
**Relations (Figure 157):** Sphenoidal air sinus and the hypophysis cerebri are medial to it. Trigeminal ganglion along with the cavum trigeminale form the posteroinferior relation of the lateral wall. Uncus also forms the retation of lateral wall. In the lateral wall of the cavernus sinus are, oculomotor, trochlear and the ophthalmic division of the trigeminal nerves from above downwards. The internal carotid artery lies within the cavernous sinus and the abducent nerve, being inferolateral to it. The artery acts as a pump and helps in venous circulation of the cranial cavity. Its superior relations are the optic chiasma and the anterior perforated substance.

**Figure 157** Showing extent of cavernous sinus and its connections with sigmoid sinus and superior bulb of internal jugular vein




**Tributaries (Figures 158 and 158A):** The superior ophthalmic veins, tributory from the inferior ophthalmic vein, superficial middle cerebral veins, inferior cerebral veins, and the sphenoparietal sinuses are the tributaries. It receives the central vein of retina, and the anterior trunk of the middle meningeal sinus. It communicates with the transverse sinus through the superior petrosal sinus the internal jugular vein through the inferior petrosal sinus.

**Figure 158** Showing connections of pterygoid venous plexus with cavernous sinus (highly schematic)



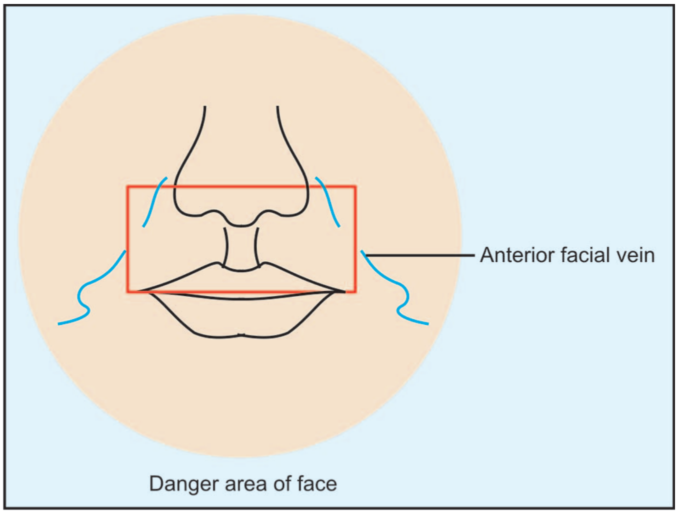



**Figure 158A** Showing danger area of face

The anterior facial vein is connected to the pterygoid venous plexus through the deep facial vein. The pterygoid venous plexus is connected to inferior ophthalmic vein which joins the cavernous sinus. Emissary veins from the pterygoid venous plexus reach cavernous sinus through the foramen ovale, emissary sphenoidal foramen or the foramen lacerum. The sinuses are interconnected through the anterior and posterior inter-cavernous sinuses. Basilar venous-plexus is connected to the cavernous sinuses through the inferior petrosal sinuses.

The venous drainage (circulation) of blood in the cranial cavity depends on three factors. They are:

1. Gravity
2. Position of the head, and
3. The pulsations of the internal carotid artery.

**Sphenoparietal Sinus:** It is situated under the free margin of the lesser wing of sphenoid. It receives small veins from the dura, and may get one of the middle meningeal sinuses. Sphenoparietal sinuses drain into the cavernous sinus.

**Clinical:** The fracture of the middle cranial fossa may result in forming an arterio-venous communication in the cavernous sinus. It is known as an arterio-venous fistula. This causes pulsating eyeball. The arteriovenous fistula of the cavernous sinus raises the cavernous sinus pressure equal to that of the systemic arterial pressure. It obstructs the venous flow from the eyeball resulting in stasis congestion and oedema of the eyeball which making it prominent. Eyeball pulsates as the pulsations of the internal carotid artery are transmitted to the eyeball. The increased pressure in central vein of the retina adds gravity the problem.

**Danger Area of the Face:** Danger area of face includes the upper lip and the alae of the nose. This area is drained by the anterior facial vein. Anterior facial vein is connected to the pterygoid venous plexus through the deep facial veins. Pterygoid venous plexus is connected to the cavernous sinus through the inferior ophthalmic vein.

An emissary vein passes through the foramen lacerum and joins the cavernous sinus (Foramen lacerum is closed by the fibrocartilagenous plate and no important structure passes through it except the two (1). Menengial branch of the ascending pharyngeal artery, and (2) the emissary vein to the cavernous sinus.

Thrombosis of the cavernous sinuses is fatal following the infection in the danger area of face. Thrombosis of the cavernous sinuses bring the intracranial circulation to stand still.

**Superior and the Inferior Ophthalmic Veins:** They runs posteriorly, join and finally open into the cavernous sinus. Inferior ophthalmic vein may open independently into the cavernous sinus. Anterior facial vein is connected to the pterygoid venous plexus through the deep facial vein. The pterygoid venous plexus is connected to the inferior ophthalmic vein which passes through the inferior orbital fissure to joins the cavernous sinus.

**Intercavernous Sinuses:** They are situated in the anterior and the posterior borders of the diaphragma sellae.

**Inferior Petrosal Sinus:** It connects the posteroinferior part of the cavernous sinus with the superior bulb of the internal jugular vein. It is lodged in between the basilar part of the occipital bone and the petrous part of the temporal bone. Vertebral venous plexus is connected with the inferior petrosal sinuses and thereby to the cavernous sinuses.

**Structures in the Jugular Foramen (Figure 159):** Inferior petrosal sinus anteriorly, internal jugular vein posteriorly and the three nerves, i.e. 9th, 10th and the 11th nerves in the middle, are the structures in the jugular foramen. ("Better said" The vein in front, the vein behind and the three nerves in between, i.e. inferior petrosal sinus in front, internal jugular vein behind and 9th, 10th and 11th nerves in between).

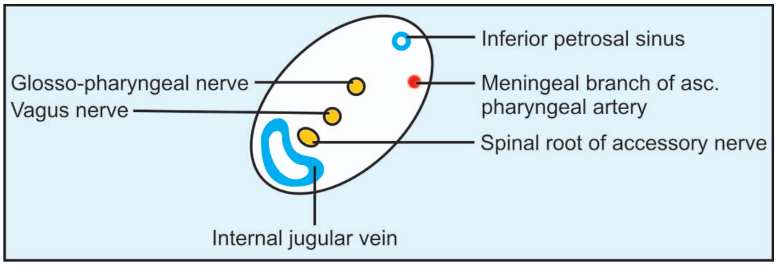



**Figure 159** Showing structures passing through jugular foramen

**Basilar Venous Plexus:** It is situated over the dorsum sallae of the sphenoid bone and the basilar part of the occipital bone. It connects the two inferior petrosal sinuses and makes an important communication with the vertebral venous plexus lower down. It has a communication with the cavernous sinus.

**Middle Meningeal Veins:** They communicate with superior sagittal sinus through their lacunae. Lower part forms the two trunks frontal and the parietal, which accompany the middle meningeal arteries. Parietal trunk may escape through the foramen spinosum and end in the pterygoid venous plexus. The frontal trunk may leave the cranial cavity through the foramen ovale and join the pterygoid venous plexus. Sometimes, it joins either the sphenoparietal sinus or the cavernous. They receive the diploic veins and make communication with the superficial middle cerebral veins.

**Sigmoid Sinuses (Figure 160):** It begins as the continuation of the transverse sinus at the base of the petrous part of the temporal bone. It runs downwards and medially occupying a deep groove on the mastoid part of the temporal bone. It crosses the jugular process of the occipital bone and enters the jugular foramen to form the superior bulb of the internal jugular vein and continues as the internal jugular vein.

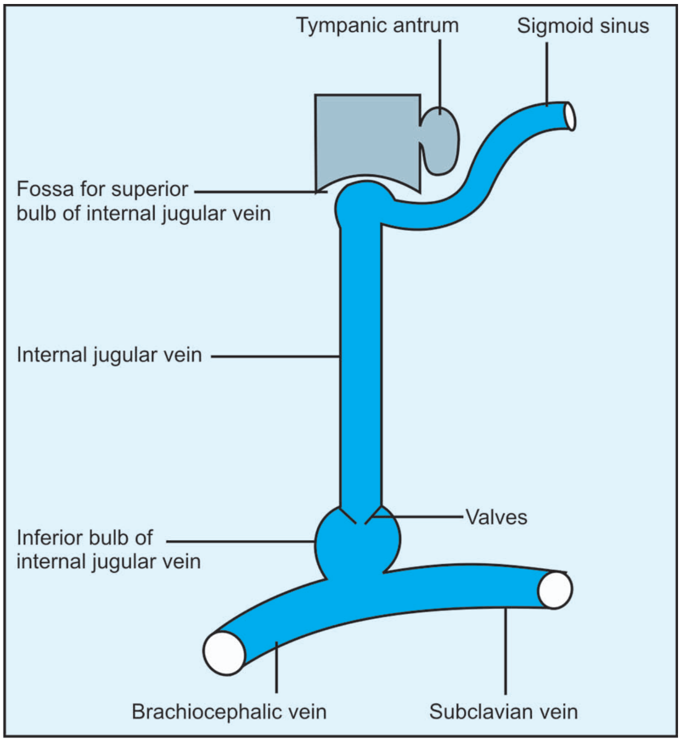



**Figure 160** Showing sigmoid sinus

**Relations:** Anteriorly, it is related to the tympanic antrum and the mastoid air cells.

**Connections:** It receives veins from the pericranium through the mastoid and condylar emissary veins.

**Occipital Sinus:** Generally single but may be paired. It emerges near the margin of the foramen magnum and drains into the confluence of the sinuses. It is also connected with the internal vertebral venous plexus.

**Frontal Air Sinuses (Figure 161):** These are small air sinuses situated in the frontal bone. They are placed above the root of the nose and the medial part of the superior margins of the orbits and are separated by a partition which is rarely median in position. Each of them is about 2.5 centimeter in length and 1.25 centimeter in breadth. They are smaller in women may remain absent. They increase in size due to the absorption by the diploe, hence they are not of an equal size. They communicates with middle meatus of the nose through the infundibulum. Maxillary air sinus opens in the middle meatus.

It has already been stated that the secretions of the frontal air sinus can reach the maxillary, hence the maxillary air sinus is called as the secondary reservoir of the frontal air sinus.

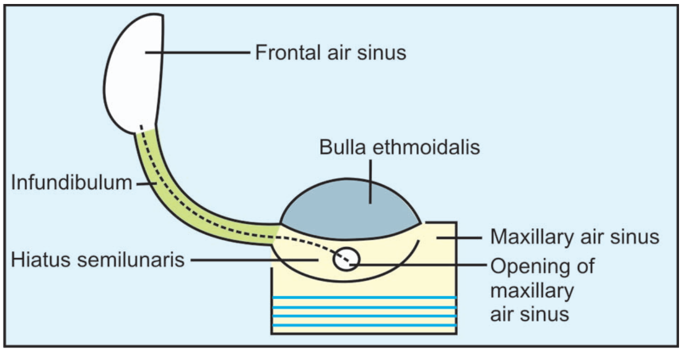



**Figure 161** Showing frontal and maxillary air sinuses and their relations. Frontal air sinus drains in maxillary air sinus

**Sphenoidal Air Sinus:** They are two sinuses usually of an unequal size, situated in the body of the sphenoid. Normally, they occupy the body of the sphenoid or a part of

it. Sometimes, they may occupy the greater wings, roots of the pterygoid process or even the basilar part of the occipital bone. It communicates with the sphenoethmoidal recess through the opening in its anterior wall.

**Relations:**

Anterior relations
- Cavity of the nose.
- ethmoid sinuses.
- sphenoethmoid recess.

Inferior relations
- Cavity of nose.
- Nasopharynx
- Pterygoid canal.

Posterior relations
- Basilar artery.
- Pons.

Superior relations
- Intercavernous sinuses.
- Pituitary body.
- Optic chiasma.

Lateral relations
- Cavernous sinus.
- 3rd nerve, 4th nerve and the ophthalmic division of trigeminal.
- Maxillary nerve along the lower border of the sinus.
- Optic foramen and optic nerve.

**Trigeminal Nerve and Ganglion (Figure 162):**

Functional components of the trigeminal nerve

1. *Special visceral efferent:* For four muscles of mastication and other four muscles
2. *General somatic afferent :* It has three nuclei:
   a. Spinal,
   b. Superior sensory, and
   c. Mesencephalic.

Spinal nucleus receives the pain and temperature sensations. Superior sensory nucleus receives touch and pressure sensations while the mesencephalic receives proprioceptive sensations.

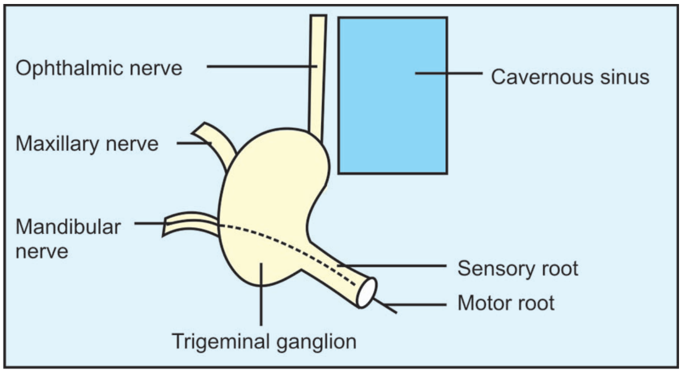



**Figure 162** Showing trigeminal ganglion, its roots, branches and relation to cavernous sinus in the middle cranial fossa

It is the important and the thickest of the cranial nerves. It has three divisions, two components and four peripheral parasympathetic ganglion related to it.

**Distribution of Motor Component:**

It supplies eight muscles. Out of them four are the muscles of mastication (medial and lateral pterygoid, temporalis and the masseter). Other four muscles are the tensor palati, tensor tympani, mylohyoid and the anterior belly of the digastric.

**Distribution of Sensory Components :**

It supplies the dura mater, eyeball, skin of the face and half of the head, mucous membranes of the paranasal sinuses, nose mouth and the temporo-mandibular joint. Morphologically it resembles a spinal nerve, having a

sensory and motor root. Situated on the sensory root is the trigeminal ganglion which is morphologically similar to the spinal ganglion or dorsal root ganglion. Trigeminal ganglion contains unipolar cells like the spinal ganglion. From the convexity of the trigeminal ganglion which is directed anterolaterally three divisions emerge. They are, the ophthalmic, maxillary and the mandibular from before backwards. Motor root of the nerve joins the mandibular nerve as it leaves the skull and it lies under the trigeminal ganglion. Sensory and the motor roots enter the middle cranial fossa by crossing the superior border of the petrous temporal bone. These roots have coverings of pia, arachnoid and the dura. It is surrounded by the subarachnoid space.

**Trigeminal Ganglion (Figures 163 and 163A):** It is also known as semilunar ganglion or Gassarian because of its shape. It is situated in a shallow depression at the apex of petrous part of the temporal bone partly overlaping the foramen lacerum. Its convex surface is directed anterolaterally and the concave posteromedially. The ganglion is situated in a special cave of a dura mater known as cavum trigeminale.

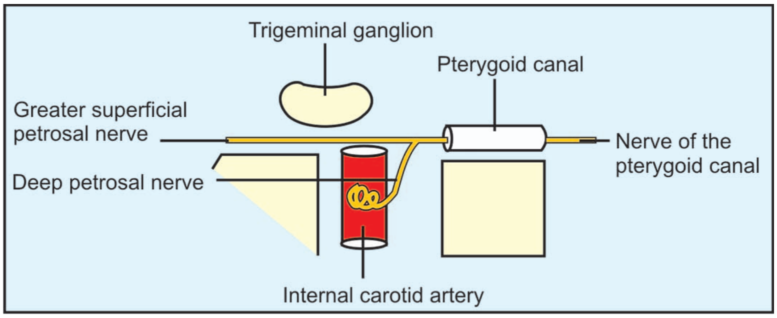



**Figure 163** Showing trigeminal ganglion and its relation with greater superficial petrosal nerve

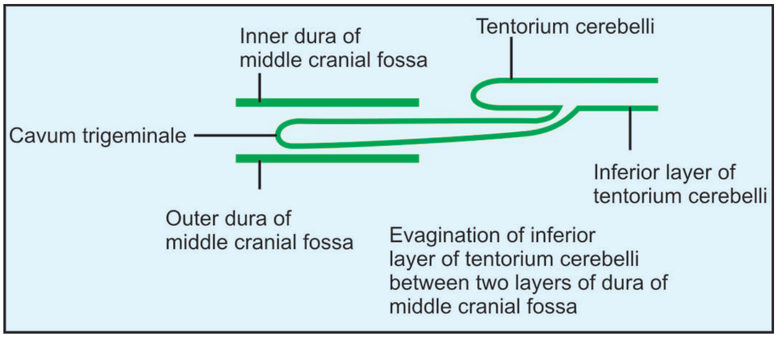



**Figure 163A** Formation of cavum trigeminale

## Relations

**Inferior Relations (Figure 163):** Motor root of the ganglion, internal carotid artery, greater superficial petrosal nerve, apex of the petrous temporal bone, sympathetic plexus round the internal carotid artery are the inferior relations.

**Medial Relations:** Medially is the lateral wall of the cavernous sinus and the structures within. It receives the filaments from the internal carotid plexus (sympathetic) and gives twigs to the tentorium cerebelli.

**Surface Marking:** This ganglion lies at the depth of about 4.5 to 5 cm from the lateral aspect of the head a little in front of the preauricular point.

**Blood Supply:** It is supplied by the middle meningeal and the accessory meningeal arteries.

**Clinical:** Damage to the trigeminal nerve results in anaesthesia of the corresponding anterior part of the scalp and face, excepting a small area near the angle of the mandible which is supplied by the greater auricular nerve, cornea, the

conjunctiva, the mucous membranes of the mouth, nose and the anterior two-third of the tongue are affected. Damage to the motor root causes paralysis of muscles of mastication.

**Referred Pain in Trigeminal Nerve:** The commonest example of the condition is the neuralgic pain which is associated with the dental caries, in which tooth itself does not appear painful, but the most distressing referred pain is experienced in the area supplied by the trigeminal nerve. Relief is obtained by removal (extraction) the affected tooth. It must be noted that anaesthesia is more common in cases of intracranial tumors. It is interesting to know that in case of the ulcer or the cancer of the tongue pain is referred to the ear and the temporal fossa area the distribution of auriculotemporal nerve.

**The Trigeminal Neuralgia:** Trigeminal neuralgia is characterised by severe pain in the area of the distribution of the trigeminal nerve. It is precipitated by movement, touch and cold. It can also occur due to the tumors in the cerebello pontine angle and also seen in vascular compression of the nerve root.

**Treatment:**

1. Relief of the trigeminal neuralgia can be obtained by injecting 90% alcohol through the foramen ovale.
2. Sectioning of the inferolateral part of the trigeminal ganglion (Rizotomy).
3. Trigeminal tractotomy at the medullary level.
4. *Neurosurgery :* This procedure is undertaken through posterior cranial fossa. The trigeminal nerve is identified leaving the brainstem and it is separated from the compressing vascular malformation by microvascular surgical techniques.

**Mandibular Nerve (Figure 164):** Mandibular nerve arises from the anterolateral convex border of the trigeminal ganglion. It gives a meningeal twig to dura mater and enters the foramen ovale to reach the infratemporal fossa through its roof, medial to the lateral pterygoid muscle and lateral to the tensor palatine.

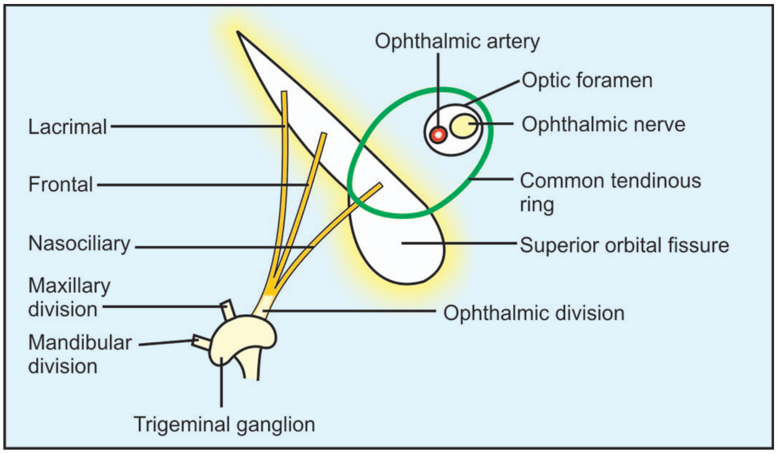



**Figure 164** Showing three branches of ophthalmic divisions of trigeminal nerve. Note: Common tendinous ring and the optic foramen

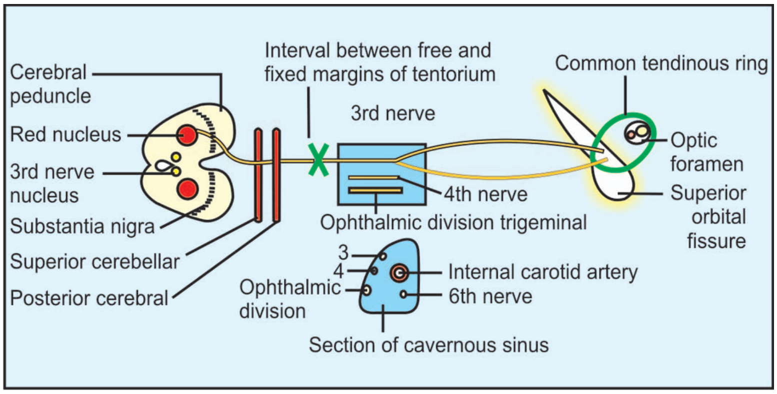
**Maxillary Nerve:** Maxillary nerve arises from the anterolateral convex border of the trigeminal ganglia and runs within the two layers of the dura mater at lower border of the cavernous sinus. Medially it is related to the sphenoidal air sinus. It gives meningeal branch to the dura mater and leaves the middle cranial fossa through the foramen rotundum.

**Ophthalmic Nerve (Figure 164):** It runs forwards in the lateral wall of the cavernous sinus below the third and the fourth cranial nerves and divides into three branches namely the lacrimal, frontal and the nasociliary. They enter the orbit through the superior orbital fissure. Ophthalmic nerve gives a branch to the tentorium cerebelli and receives sympathetic filaments from the plexus around the

internal carotid artery. In addition to this it gives filaments to the oculomotor, trochlear and abducent nerves.

**Oculomotor Nerve (Figure 165):** It appears on the medial side of the cerebral peduncles in the inter peduncular fossa and runs forwards and laterally between the posterior cerebral and posterior superior cerebellar arteries. It pierces the triangular interval between the free and fixed margins of the tentorium cerebelli after crossing. It runs in the lateral wall of the cavernous sinus dividing into superior and inferior divisions which enter the orbit through the superior orbital fissure within the common tendinous ring.

**Figure 165** Showing course of the oculomotor

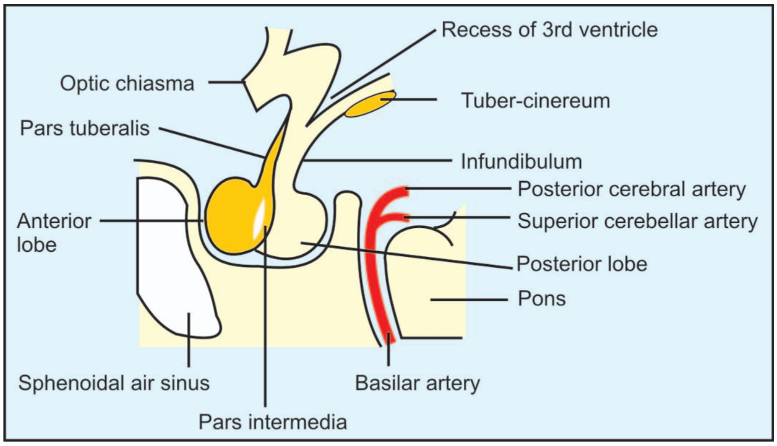



**Abducent Nerve:** Its nucleus is situated in the floor of the fourth ventricle under the facial colliculus. Facial colliculus is produced by winding of the fibres of the seventh around the nucleus of the sixth. It leaves the pons from the ventral aspect between the lower border of the pons and the upper border of the pyramid. It runs forwards, upwards, laterally and pierces the dura mater 1.25 cm, below the dorsum sellae. At the apex of the petrous temporal bone. It passes under the petrosphenoid ligament and enters the cavernous sinus. In the cavernous sinus it is inferolateral to the internal carotid artery.

## Hypophysis Cerebri (Figure 166)

It is also known as pituitary gland. It is situated in the fossa for the hypophysis cerebri in the body of the sphenoid bone under cover of diaphragma sellae. It is connected to the tubercinerium by the infundibulum which passes through the opening in the diaphragm. The pituitary gland is oval and flattened from before backwards. Its transverse diameter is 12 mm and the anteroposterior being 8 mm. It weighs about 500 mg.

**Figure 166** Showing hypophysis cerebri (sagittal section)



## Relations

**Inferior:**

They are:
1. Below sphenoidal air sinuses
2. Anteirorly optic chiasma
3. Posteriorly pons and the basilar artery
4. Laterally it is related to the cavernous sinuses.

**Coverings of the Hypophysis:**

It has a capsule which is fixed to the meninges. Deep and the superficial layers of the dura unite to form the diaphragma sellae which cover for the hypophyseal fossa. Infundibulum is directed forwards and downwards passing through an opening in the diaphragm sellae. It contains the recess from the cavity of the third ventricle. It is surrounded by an upward extension from the anterior lobe of the gland known as the tuberalis. Hypophysis cerebri has two lobes anterior and the posterior lobes. Anterior lobe is known as adenohypophysis and the posterior as neurohypophysis. Between the two lies the pars intermidia. The reminder of the anterior lobe is known as pars distalis. Adenohypophysis includes pars anterior, pars infundibular and pars tuberalis. Neurohypophysis includes the posterior part of the hypophysis.

## Histology

**Anterior Lobe:**

It consists of epithelial cells of varying sizes and shapes arranged in cords like trabeculae, irregular masses or alveoli separated by thin walled sinusoids, having chromaphil and chromophobe cells. Chromaphil cells are further classified into the alpha and the beta cells. Alpha cells present the chromaphil granules and the beta cells basophilic. Chromophobe cells are about 50 percent number. They are smaller and have no granules and contain pale staining granules. Alpha cells of the anterior lobe of pituitary produce somatotrophic, mamotrophic, corticotrophic hormones. Beta cells produces thyrotrophic, gonadotrophic and luteotrophic harmones. Intermediate lobe of the pituitary produces melanocyte stimulating hormone.

Chart showing the hormones of the anterior, posterior and intermediate lobes of the pituitary

| *Anterior Lobe* | *Middle/Intermediate Lobe* | *Posterior Lobe* |
|---|---|---|
| 1. Somatotrophic Hormones (STH, GH) | 1. Melanocytes stimulating hormone. (MSH) | 1. Oxytocin |
| 2. Thyrotrophs (TSH) | | 2. Vasopressin above |
| 3. Gonadotrophs hormone (FSH) | | Above hormones are from the hypothalamous from supraoptic and paraventricular nuclei. |
| 4. Mammotrophs secrete lactogenic hormones. | | |
| 5. Corticotrophs hormone (ACTH) | | |
| 6. Luteotrophs (LH and ICSH) | | |

**Posterior Lobe:**

Although the lobe has the neural origin it does not contain nerve cells. It contains neuroglial cells and the fibres. There are peculiar cells and are known as the pituicytes. They are of various sizes and shapes and many of them show long branching processes.

## Hormones Related to Posterior Lobe are Vasopressin (ADH) and Oxytocin

Vasopressin acts on kidney tubules while the oxytocin acts on uterine and mammary musculature. These hormones are manufactured in the hypothalamus and are transmitted to the posterior lobe of the pituitary through the long axons of the nerve cells of the supra optic and paraventricular nuclei.

**Pars Intermedia:** It contains small granular cells with beta cells in the part adjoining the posterior lobe. In between the cells are the small masses of colloid material. Pars tuberalis is traversed by number of vessels between which we get cords or masses of undifferentiated cells along with some alpha and beta cells.

**Blood Supply:** Anterior lobe of pituitary is supplied by two sources, i.e. arterial and the portal. Branches of the superior-hypophysial arteries form the plexus in the median eminence. This is known as primary plexus. Long and short portal veins arise from the primary plexus and reach pars distalis through the median eminence. Portal veins break and form the secondary plexus in the pars distalis.

Hypophysial portal veins begin in the capillaries of the median eminence and finally terminate into adenohypophysis (pars distalis). It carries hormones from the hypothalamus to the adenohypophysis.

**Blood Supply of the Anterior Lobe: (Pars Distalis)** Anterior lobe is supplied by one superficial and several inferior hypophycial arteries, the branches internal carotid arteries.

**Blood Supply of the Posterior lobe (Pars Distalis):** Posterior lobe is supplied by the branches of the inferior hypophycial arteries.

**Venous Drainage:** Venous blood of the pituitary go to the cavernous or inter cavernous sinuses or venous sinuses nearby. They carry hormones to the different parts of the body.

**Development:** Anterior lobe is developed from the ectodermal evagination from roof of mouth known as Rathkes pouch. Posterior lobe develops from the descending process from the floor of the third ventricle, i.e. cavity of diancephalon. Sometimes a patent canal runs between the roof of the mouth to the floor of the hypophyseal fossa. It is known as craniopharyngeal canal. Tumors arising from the canal are known as craniopharygeomas.

**Pharyngeal Hypophysis:** In the roof of the nasopharynx there is a collection of adenohypophyseal tissue. It is vascularised and can produce secretions. It may becomes the source of adenohypophycial harmones in middle aged women, when adenohypophysis starts failing.

**Clinical:** Pressure on the optic chiasma may lead to bitemporal hemianopia, and the pressure on the floor of the third ventricle to polyuria and polydyspia. Important diagnostic clues may be provided by the X-ray showing enlargement of the sella turcica and erosion of the clinoid processes. Along the craniopharyngeal canal, cysts may grow and get sequestreted and calcified. Tumors of the pituitary gland produce following conditions.

1. *Frohlich's syndrome*: It presents a fatty backward person without secondary sexual characters. (dystrophia adiposogenitalis).
2. Cysts from the remnants of craniopharyngeal canal may get infiltrated with lime (calcium salts) which is diagnosed radiologically.

3. Tumors of the pituitary may press the optic chiasma and cause bitemporal hemianopia.
4. Removal of the gland is not compatible with life.
5. Large tumors of the pituitary can compress the third ventricle leading to increased intracranial pressure.
6. Acidophilic adenoma causes acromegaly in adults and gigantism in children. Acromegaly presents with thick skin, over growth of the jaw and the distal phalanges.
7. Basophilic adenoma presents as Cushing's syndrome. It is produced by excessive formation of corticotrophin.
8. Hypopituitarism can result due to chromophobe adenoma.
9. Damage to the posterior lobe leads to diabetes incipidus which may be due to hypothalmic damage.
10. Tumors of the pituitary above the diphragma celli are known as supracellar and one below is known as infracellar. Transcranial approach is adapted for supracellar tumors. Infracellar tumors can be reached through the trans-sphenoidal, trans-ethmoidal approaches.
11. Pituitary adenomas are the commonest.
12. *Pituitary apoplexy :* There is rapid increase in the size of the pituitary tumors due to hemorrhage or in-fract. The condition is similar to the sub-arachnoid hemorrhage clinically. An emergency surgical exploration is indicated.
13. *Cushing's syndrome:* A female presents with abnormal deposition of fat in the supraclavicular region, moon shaped face buffalo hump (deposition of the fat over the spinus process of vetebra prominence.). Prominent and protruding abdomen and thin legs and arms. It has been classically described as "lemon on match-stick" appearance.

**Intracranial Part of Internal Carotid Artery (Figure 167A):** It enters the carotid canal, ascends upwards forwards and medially where it enters the foramen lacerum at the apex of the petrous part of the temporal bone. It pierces the outer layer of the dura mater and enters the cavernous sinus. It bends at right angle and runs forwards along the side of the body of the sphenoid to the root of lesser wing of sphenoid. Here it runs upwards and leaves the cavernous sinus by piercing the inner layer of the dura mater at the medial to the anterior clinoid process. Optic nerve is seen in front of it in the optic foramen. The artery pierces the arachnoid mater immediately after piercing the dura. It makes a sharp backwards bend and runs backwards above the cavernous sinus. Finally it bends upwards again and gets exhausted on the under surface of the brain by giving anterior and middle cerebral arteries. During its course it is surrounded by sympathetic plexus.

**Branches of the Internal Carotid Artery in the Skull:**

1. During its course through the cavernous sinus it gives number of small twigs to the dura mater, the trigeminal ganglion and the hypophysis. (pituitary gland)
2. Ophthalmic artery arises from it soon after it emergence from the cavernous sinus.
3. At the base of the brain, it gives posterior communicating and the anterior choroidal arteries.
4. Anterior and middle cerebral arteries.

**Greater Superficial Petrosal Nerve:** It arises from geniculate ganglia of the facial nerve in the petrous part of the temporal bone. It emerges from the bone through a slit on the antero-latero surface of the petrous part of the temporal bone. It passes deep to the trigeminal ganglion and enters the foramen lacerum, where it joins the deep petrosal nerve to form nerve of the pterygoid canal.

**Deep Petrosal Nerve:** The deep petrosal nerve arises in the foramen lacerum from the sympathetic plexus around the internal carotid artery and joins the greater superficial to form the nerve of the pterygoid canal. Nerve of the pterygoid canal runs forwards through the root of the pterygoid process, and enters the pterygo-palatine fossa. It ends in the spheno-palatine ganglion where the fibres for the lacrimal gland get relayed. Pterygo-palatine ganglion is suspended from the maxillary nerve by two roots.

**Lesser Superficial Petrosal Nerve:** Tympanic branch of glosopharyngeal nerve enters the middle ear cavity and forms a plexus over the promontary. This plexus is joined by the branch from the facial. Lesser superficial petrosal nerves arises from tympanic plexus and leaves the middle ear cavity, through an opening which lies lateral to the opening for the greater superficial petrosal nerve. In the floor of the middle fossa. It leaves the skull through a small unnamed foramen located near the foramen ovale, and joins in the otic ganglion where the secretomotor fibres for the parotid gland are relayed.

**Parts seen after Removal of Hind Brain** Vertebral canal is seen occupying by the upper end of the spinal cord. Spinal cord is attached to the margin of the foramen magnum by the first pair of ligamentum denticulatum. Medulla oblongata passes through foramen magnum. Vertebral artery lies in front of the ligamentum denticulatum and the spinal root of the accessory nerve is seen ascending through the foramen magnum behind. The glosopharyngeal, vagus, facial and the statoacoustic nerves in the posterior cranial fossa. In addition to this the trigeminal, abducent and the trochlear nerves are seen. Vertebral artery pierces the dura and immediately, enters the cranial cavity through the foramen magnum. It lies between the hypoglosal and the first cervical nerves. The artery gives meningeal branch to the posterior cranial fossa.

**Flax Cerebelli:** It is a small dural fold attached to the internal occipital crest in the posterior cranial fossa and in the posterior notch of the cerebellum. Superiorly it is attached to the tentorium cerebelli and inferiorly fades away near the foramen magnum.

**Dura Mater of the Base of the Skull:** It is firmly attached not only to the sutures but also to the intervening portion of the bones of the base of the skull.

It is continuous with the periosteum on the outer surface of the skull. At the foramen magnum outer layer gets fused with the periosteum at the margin of the foramen magnum and the inner layer of the dura continues as the spinal dura matter.

**Diploic Veins:** These are the wider venous spaces in the diploe of the flat bones of the skull. They freely communicate with each other. They are lined with endothelium, and do not have valves or muscular wall. Radiographs of the skull may show the diploic veins as relatively transparent lines. They are absent at birth and are formed at the age of two. They communicate with the meningeal veins, cranial venous sinuses and the veins of the pericranium.

Following are the diploic veins (Figure 167):

1. *Frontal:* opens into supra-orbital vein.
2. *Anterior temporal*: It is related to frontal bone and opens into the sphenoparietal sinus or anterior deep temporal vein.
3. *Posterior temporal:* It is related to the parietal bone and opens into the transverse sinus.
4. *Occipital diploic vein* : It opens into the occipital vein or into the transverse sinus.

In addition to these there are number of small diploic veins which open into the venous lacunae, near the superior sagittal sinus.

Figure 167 Showing diploic veins

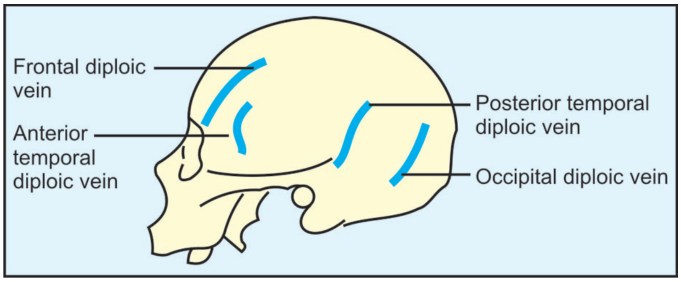
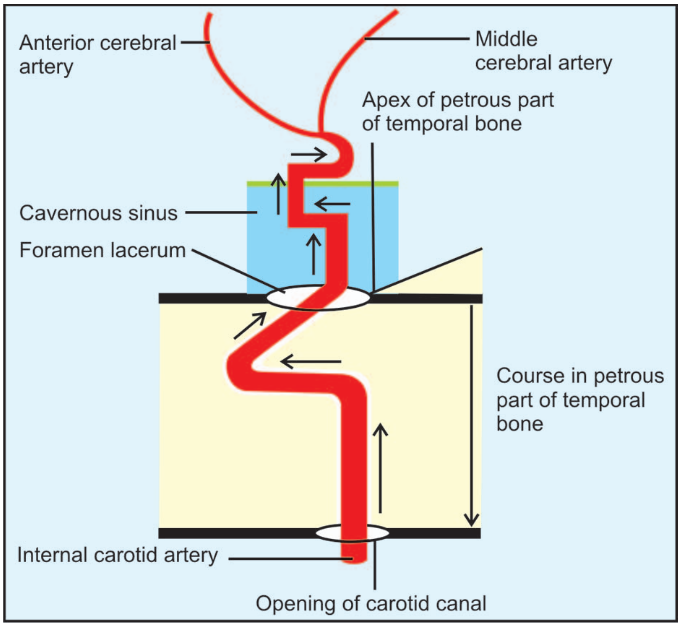



Figure 167A Showing intracranial course of internal carotid artery




**Emissary Veins:** They pass through the foramina in the skull and establish connections with the intracranial venous sinuses. Blood can run in either direction and thus it helps in equalising venous pressure within and outside the skull. This carries the risk of spreading infection in and out of the skull.

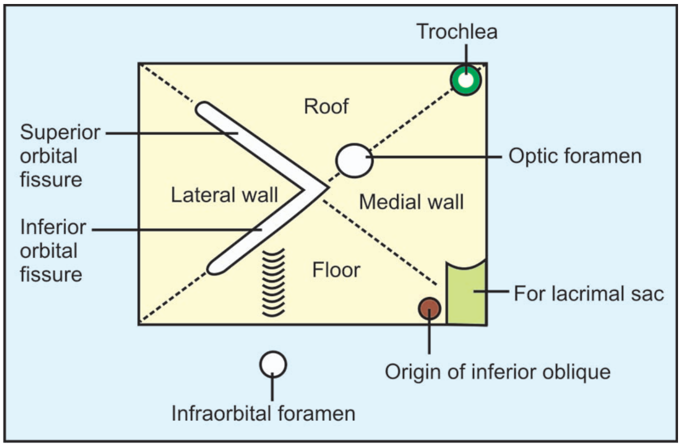
1. *Mastoid emissary vein:* Mastoid emissary vein runs through the mastoid foramen, and connects the sigmoid sinus with the posterior auricular vein or the occipital vein.
2. *Parietal emissary vein:* It passes through emissary parietal foramen. It connects the superior sagittal sinus with the veins of the scalp.
3. *Anterior condylar emissary vein:* Anterior condylar emissary vein joins the sigmoid sinus with the internal jugular vein.
4. *Posterior condylar emissary vein:* Posterior condylar emissary vein connects veins of the sub-occipital triangle with sigmoid sinus.
5. The plexus of emissary veins which connect the cavernous with the pterygoid venous plexus.
6. Emissary veins which connect the cavernous sinus with the pterygoid venous plexus through the foramen lacerum.
7. Vein of the emissary sphenoidal foramen.
8. Venous plexus accompanying the internal carotid artery. It connects the cavernous sinus with the internal jugular vein.
9. Petro-squamous sinus connects the transverse sinus with the external jugular vein.
10. Emissary vein passes from the nose through foramen caecum when patent.

**Clinical:** Emissary veins have bi-direction blood flow, helping entry and exit of blood in and from the cranial cavity.

# ORBIT

**Bony Orbit (Figure 168):** Eyes are well protected inside the bony orbits, which also contains, muscles, nerves, vessels including optic nerve and eyeball. Orbit is roughly like a quadrilateral pyramid, having its base or the orbital opening directed anterorolaterally and the apex postero-medially, near the optic foramen. It is triangular in cross section near the apex, because the floor is the shortest wall and does not reach the apex. The direction of the axis of the orbit is forwards outwards and slightly downwards.

**Figure 168** Showing bony orbit from the front




**Roof:** Roof is related to the anterior cranial fossa and the frontal air sinuses. The two medial walls are almost parallel however the lateral walls meet at an angle of 90° if extended.

**Medial Wall:** Medial wall is related to the nasal cavity, ethmoidal sinuses, sphenoidal air sinuses and the ethmoid canaliculii. Medial wall is thin and seen as broken.

**Interior Wall:** The maxillary antrum

**Lateral Wall:** The temporal fossa. It is the thickest wall formed by the orbital surface of the zygotic bone anteriorly and the greater wing of the sphenoid posteriorly.

**Floor :** Floor is triangular in shape and is the shortest of all the walls. It is formed by three bones:

1. Orbital plate of maxilla,
2. Orbital surface of zygomatic bone and
3. Orbital process of palatine.

**Infra-orbital Sulcus:** It runs forwards from the inferior-orbital fissure. Anteriorly it is converted into the canal, which opens at the infra-orbital foramen, about 4 mm below the inferior orbital margin. It is occupied by the infra-orbital vessels and nerve.

**Origin of Inferior Oblique:** It arises from a small pit situated lateral to the opening of the nasolacrimal canal.

**Relations:** Inferior rectus muscle is in contact with the floor of the orbit at the apex but separated from the floor by the inferior oblique muscle anteriorly. Nerve to the inferior oblique is related to the lateral margin of the inferior oblique muscle. Infra-orbital vessels and nerve run in the groove on the floor. Floor is related to the maxillary air sinus below. Because of this

proximity, growths from the maxillary air sinus easily invade the orbit through the floor which results in proptosis (eyeball is pushed forwards).

**Lateral Wall (Figure 169):** It is triangular in shape. It is formed by the orbital surface of the zygomatic bone anteriorly and the orbital surface of the greater wing of the sphenoid posteriorly. It is the strongest wall.

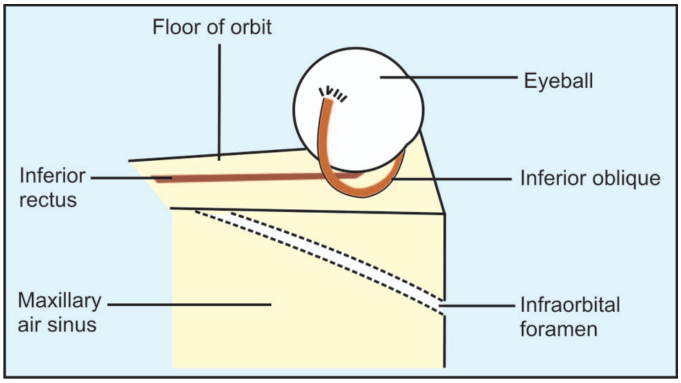



**Figure 169** Showing inferior oblique muscle of eyeball

**Spini Recti Lateralis of Superior Orbital fissure (Figure 170):** It is presents as a spine on the inferior border at the junction of its wide medial and the narrow lateral portions.

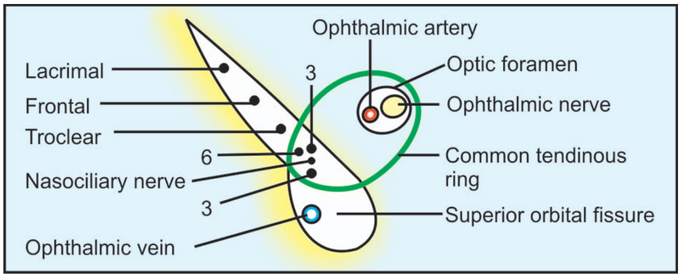



**Figure 170** Showing structures passing through superior orbital fissure

Inferior orbital fissure is placed between the floor and the lateral wall. Zygomatic nerve and vessels run from the anterior end of the inferior orbital fissure and run into the canal and divides into zygomatic and temporal branches. Inferior orbital nerve enters the orbit through the inferior orbital fissure.

**Lateral Orbital Tubercle (Tubercle of Whitnell):** It is situated 11mm below the frontozygomatic suture. It gives attachment to the lateral palpable ligament.

**Roof:** Roof is triangular in shape. It is formed by orbital plate of the frontal bone anteriorly and the lesser wing of the sphenoid posteriorly. At its antero-lateral angle it presents a fossa for the lacrimal gland. At its antero-medial angle it presents a small circular pit which gives attachment to the cartilaginous pully (trochlea) for the superior oblique muscle.

Medial wall is formed by 4 bones from before backwards: (1) Frontal process of maxilla, (2) Lacrimal, (3) Ethmoid and (4) The lateral aspect of the body of the sphenoid bone.

**Lacrimal Groove:** It lies at the anterio-medial angle of the floor. It is formed by the frontal process of maxilla and the lacrimal bone. It is bounded by anterior and posterior lacrimal crests. Lower down the fossa lodges the lacrimal sac and is continuous with naso-lacrimal duct which opens in the inferior meatus of the nose. It is surrounded by lacrimal fascia. Horner's muscle, septum orbitale and cheek ligament of medial rectus muscle form the posterior relations of the sac.

**Orbital Periosteum (Figure 171):** It forms a funnel shaped sheath for all the contents of the orbital cavity except the zygomatic and the infraorbital nerves and vessels. Posteriorly it is continuous with the outer layer of the dura of the middle cranial fossa through the superior orbital fissure and the optic foramen. Anteriorly it is continuous with the periosteum at the orbital margin. Its attachment to the bony walls is not firm and has an important connections with the palpebral fascia. It splits into two layers to enclose the lacrimal sac. Optic foramen is bounded by the two roofs of the lesser wing of the sphenoid.

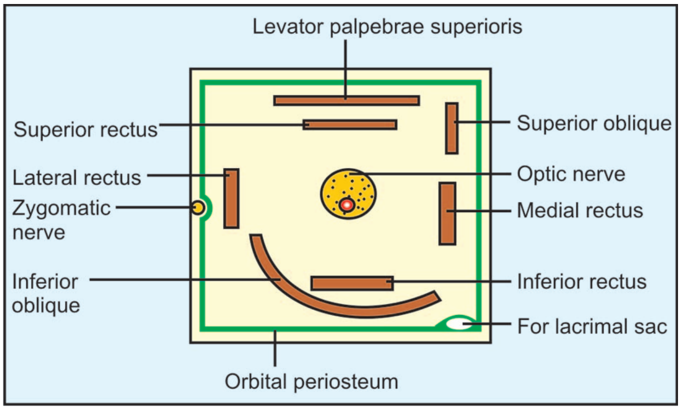



**Figure 171** Showing general arrangement of structures in orbit and orbital periosteum

**Frontal Nerve (Figure 172):** It appears as a continuation of the stem of the ophthalmic nerve. It enters the orbit through the superior orbital fissure, and runs anteriorly under the periosteum, on the levator palpebrae superioris muscle. It divides into a supratrochlear and supraorbital nerves on the forehead.

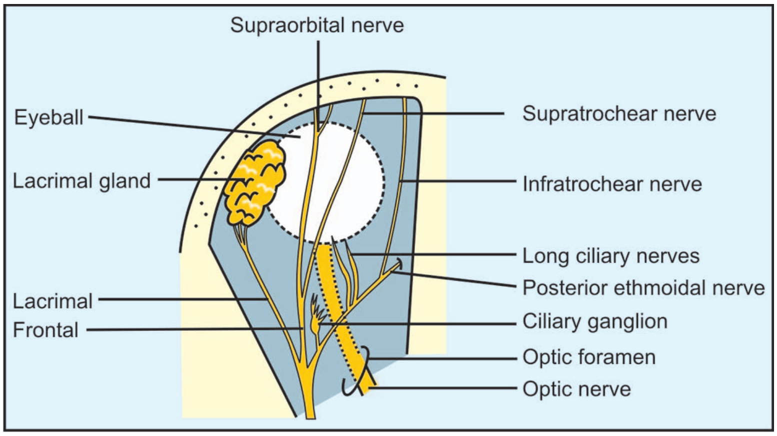



**Figure 172** Showing nerves of orbit after removal of the roof of orbit

**Supratrochlear Nerve:** It enters the supraorbital notch or the foramen and enters the region of the forehead.

**Lacrimal Nerve (Figure 172):** Lacrimal nerve enters the orbital cavity through the lateral part of the superior orbital fissure, outside the common tendinous ring. It receives a small filament from the maxillary nerve through which secretary fibers reach the lacrimal gland. Anteriorly it gives a branch to the lacrimal gland and to the lateral part of the upper lid.

**Trochlear Nerve:** Trochlear nerve supplies the superior oblique muscle. It enters the orbit through superior orbital fissure, out side the common tendinous ring.

**Lacrimal Gland:** Lacrimal gland is situated in the hollow on the medial side of the zygomatic process of the frontal bone at the antero-lateral angel of the roof of orbit. It is fixed to the orbital margin by short fibrous bands. Its deep surface is concave and is in contact with the levator palpebrae superioris and the lateral rectus muscles. Mention has already been made about its palpebral part and the ducts (Please see lacrimal apparatus).

**Nerve Supply:** Secretory nerves of this gland are derived from the pterygopalatine ganglion, through its orbital branches and the filaments to the lacrimal nerve from the zygomatic nerve.

**Levator Palpebrae Superioris:** Levator palpebrae superioris lies on the superior rectus muscle. It arises from the orbital roof imediately in front of the optic foramen. It is inserted into the skin, superior tarsal plate and the superior conjuctival fornix.

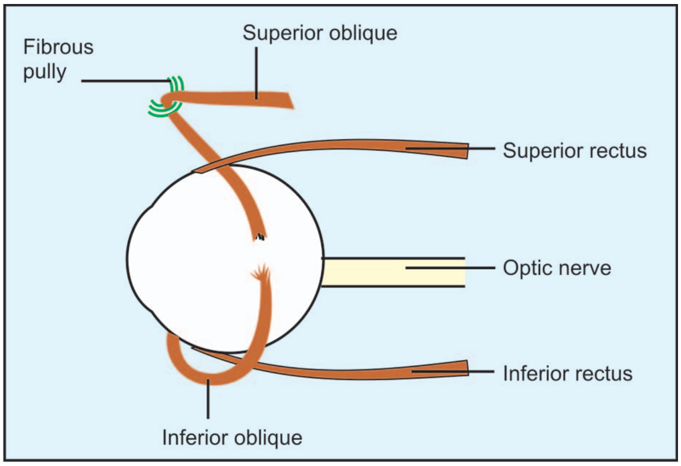
**Nerve Supply:** It is supplied by the upper division of the oculomotor nerve.

**Action:** It is an elevator of the upper lid and the superior conjuctival fornix.

**Superior Rectus:** Superior rectus lies below the levator palpebrae superioris muscle. It arises from the upper margin of the optic foramen, and gets inserted into the eyeball about 8 mm behind the sclero-corneal junction.

**Nerve Supply (Figure 173):** It is supplied by the upper division of the oculomotor nerve.

**Figure 173** Showing superior and inferior oblique muscle with superior and inferior recti




**Action:** Superior rectus turns the centre of the cornea upwards and medially. The medial deviation is associated with some degree of rotation. The medial deviation is due to the fact that superior rectus muscle does not run only forwards but also laterally. This oblique course of the muscle, complicates the action. Normally this action is corrected by the inferior oblique muscle, whose action is to move the cornea upwards and laterally.

**Obliquus Superior:** Obliquus situated at the medial side of the orbit. It arises from the body of the sphenoid above and part medial to the optic canal. It passes forwards to form a tendon which runs through the fibrocartigenous pully attached to the trochlear fossa of the frontal bone at the anteromedial angle of roof of the orbit. After its course through the pully it turns backwards, laterally and downwards below the superior rectus for insertion into the sclera in the postero-lateral quadrant of the eyeball, between the superior and the lateral recti.

**Nerve Supply:** It is supplied by the trochleal nerve.

**Action:** It turns the centre of the cornea downwards and laterally.

**Obliquus Inferior (Figure 173):** It arises from the orbital surface of the maxilla lateral to the naso-lacrimal groove. It runs laterally, backwards and upwards first between the inferior rectus and the floor of the orbit and then between the eyeball and the rectus lateralis. It is inserted into the lateral part of the sclera behind the equator or the eyeball between the superior rectus and lateral rectus muscle, but somewhat behind the insertion of the superior oblique.

**Nerve Supply:** It is supplied by nerve to inferior oblique a branch of the inferior division of the oculomotor nerve. It is the only nerve which enters the orbital muscle through its posterior border. All other nerves enter the orbital muscles through their ocular surfaces.

**Action:** It turns the centre of the cornea upwards and laterally.

**Medial Rectus Muscle (Figure 174):** Arises from the medial part of the fibrous ring and also from the dura of the optic nerve. It passes along the medial wall of the orbit below the superior oblique muscle, pierces the facial covering of the eyeball and gets inserted into the sclera behind the sclero-corneal junction.

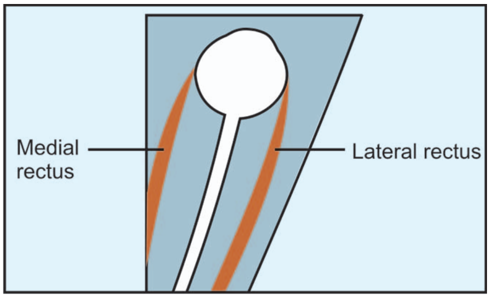



**Figure 174** Showing medial and lateral recti

**Lateral Rectus:** Lateral rectus arises by two heads from the lateral part of common tendinous ring and gets inserted into eyeball behind the sclero-corneal junction.

**Action:** It turns the centre of the cornea laterally.

**Nerve Supply:** It is supplied by abducent nerve.

**Action:** It deviates the centre of the cornea laterally in the horizontal direction.

**Inferior Rectus:** Inferior rectus arises from the lower part of the fibrous ring, runs forwards and laterally pierces the fascia bulbi and gets inserted into the inferior surface of the sclera, behind the sclerocorneal junction.

**Nerve Supply:** It is supplied by the inferior division of the oculomotor nerve.

**Action:** Inferior rectus depresses the centre of the cornea and deviates it to the medial side. The later action is compensated by superior oblique muscle.

**Detailed Actions of the Orbital Muscles:** Orbital muscles are divided into voluntary and involuntary. The voluntary muscles are, four recti and two obliqui. Involuntary muscles are three. (Figure 175).

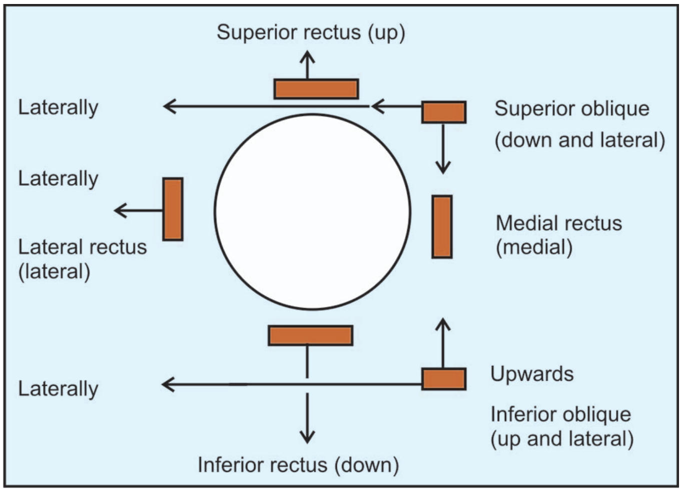



**Figure 175** Showing the actions of the muscles of the eyeball (diagramatic)

1. *Superior tarsal muscle or Muller's muscle:* It is a part of levator palpebrae superioris and is attached to the superior border of the superior tarsal plate.
2. *Inferior tarsal muscle:* It is an extended muscular strip running from the inferior rectus and inferior oblique muscles to the inferior tarsal plate. Superior tarsal muscle elevates the upper lid while the inferior tarsal muscle depresses the lower lid.

3. *Orbitalis:* It is present at the inferior orbital fissure and makes a futile attempt to close it. However no important function has been attributed to this muscle.

   Discussion with special reference to extra occular muscles and their actions:

For the eyeball there are three axis
1. Visual
2. Vertical
3. Horizontal

Medial and lateral rotation occurs along the vertical axis, the elevation and depressions occurs along the transverse axis. The intorsion and extortion occur along the visual axis with reference to the 12'O clock position of the corneal margin.

The superior rectus and the inferior rectus make an angle of 25 degrees lateral to the visual axis in the primary position of the eyeball, therefore it is only in the abducted position of the eyeball, the axis of the muscle coincide with the visual axis.

Superior and oblique muscles are at an angle 51 degree medial to the visual axis. Therefore only in the adducted position the visual axis coincides with the axis of the muscles.

To summarise the following information is given in brief (Figure 175)

**Actions of Muscle of Eyeball:**

| | | |
|---|---|---|
| 1. | Adduction | Medial, superior and inferior recti. |
| 2. | Abduction | Lateral rectus, superior oblique and inferior oblique muscle |
| 3. | Elevation | Superior rectus and inferior oblique. |
| 4. | Depression | Inferior rectus and superior oblique. |
| 5. | Intortion | Superior rectus and superior oblique |
| 6. | Extorsion | Inferior rectus and inferior oblique. |

**Fundascopic Picture (Figures 186A and B):** It is seen through the ophthalmoscope. Optic disc is seen 3 mm medial to the macula leutea. Branches of the ophthalmic artery enter above and below the optic disc. Each group divides into nasal and temporal branches. Veins leave the eyeball at the same place. Central vein of the retina which runs in the subarachnoid space is subjected compression when the intracranial pressure rises which leads to papilledema. Macula leutea is situated 3 mm lateral to the optic disc. It is avascular and yellow. It is depressed in the center and is known as fovea centralis. It contains only the cones and this is the site of maximum visual aquity. It is interesting to note that the branches of the ophthalmic artery can be viewed directly only in the fundascopy of the retina.

**Optic Nerve:** Optic nerve is the 2nd cranial which is thickest among the cranial nerves. As it enters the orbit through the optic foramen, it carries with it a strong but loose sheath of the dura matter, a covering of the arachnoid mater and the pia. Naturally it is surrounded by the subarachnoid space which is continuous with the subarchnoid space of the cranium. Optic nerve is slightly longer than the distance which it has to cross. This extra-length of the nerve helps in free movements of the eyeball. (It is accompanied by the ophthalmic artery which has a wavy course along with the nerve.) After its entry into the orbit through the optic foramen it runs forwards, laterally, with a slight downwards inclination to pierce the sclera at a point situated medial to the centre of the back of the sclera. It is surrounded by the ciliary nerves and the vessels near the eyeball, and is crossed by the ophthalmic

artery, vein and the nasociliary nerve, superficially, from lateral to the medial side.

**Nasociliary Nerve (Figure 176):** It arises from the ophthalmic nerve in the anterior part of the cavernous sinus itself. It passes through two heads of the lateral rectus muscle (within the common tendinous ring) in between the two divisions of oculomotor nerve. It runs forwards and medially above the optic nerve and reaches the medial wall of the orbit. It runs forwards and medially between the medial rectus the superior oblique muscle.

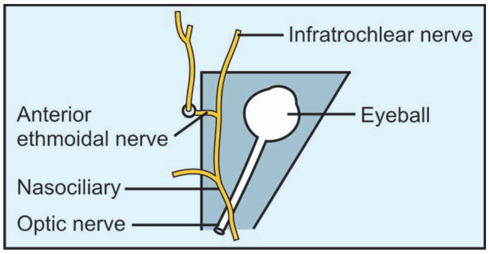



**Figure 176** Showing nasociliary and the anterior ethmoidal nerve

**Branches:** In the anterior part, it divides into two terminal branches, the infratrochlear and the anterior ethmoidal. It also gives a branch to the ciliary ganglion, long ciliary nerves and the posterior ethmoidal nerve.

**Communicating Branch:** Communicating branch to the ciliary ganglion arises from the nasociliary nerve as it enters the orbit. This communicating twig runs along the lateral side of the optic nerve, to the ciliary ganglion for the relay.

**Long ciliary nerves:** Nasociliary nerve crosses the optic nerve, and it gives two long ciliary nerves. Long ciliary nerves are the sensory nerves of the eyeball. Sympathetic fibres associated with the nerve are distributed to the dilator pupil muscle, from the superior cervical ganglion through the internal carotid artery.

**Posterior ethmoidal nerves:** It arises from the nasociliary along the medial wall of the orbit. It gives branches to the mucous lining of the ethmoidal and sphenoid air sinuses. Posterior ethmoidal nerves enters through the posterior ethmoidal foramen.

**Infratrochlear nerve:** It arises from the nasociliary along the medial wall of the orbit below the eyeball. It gives branches to the eyelid and the upper half of the external nose.

**Anterior Ethmoidal Nerve (Figure 177):** It escapes from the orbit by passing through the anterior ethmoidal canal, which takes it to the cranium. Next it appears at the lateral margin of the cribriform plate of the ehthmoid bone. The canal for the nerve lies in the roof of the ethmoidal air sinuses. It enters the nasal cavity through a small slit at the side of the crista galli. It runs between the mucous membrane and the nasal bone, and finally comes to the face between the lower margin of the nasal bone and the upper cartilage of the nose. Lower half of the skin of the nose is supplied by the external nasal nerve.

**Cilliary Ganglion (Figures 178 and 179):** It is peripheral parasympathetic ganglion of a size of a head of a pin. It is situated at the apex of the orbit amongst fat between the optic nerve medially and the lateral rectus muscle laterally, it has three roots.

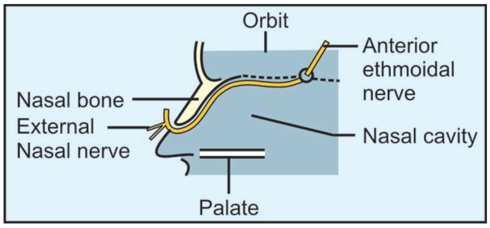



**Figure 177** Showing course of the anterior ethmoidal nerve which continue as external naso nerve

1. *Sensory :* Comes from the nasociliary nerve and goes out without relay.
2. *Motor (parasympathetic):* Comes from the nerve to the inferior oblique muscle a branch of the oculomotor nerve. It gets relayed in the ganglia.
3. *Sympathetic:* Comes from the sympathetic plexus round the internal carotid artery in the cavernous sinus and pass through the ganglion without relay.

The ganglion gives number of short ciliary nerves which are about 6-8 in number. They pierce the sclera, where they divide to form about 12-20 small nerves. Sensory and sympathetic roots pass through the ganglion without relay, only the parasympathetic fibres are relayed in the ganglion.

**Figure 178** Showing ciliary ganglion at the apex of orbit between the optic nerve medially and lateral rectus laterally

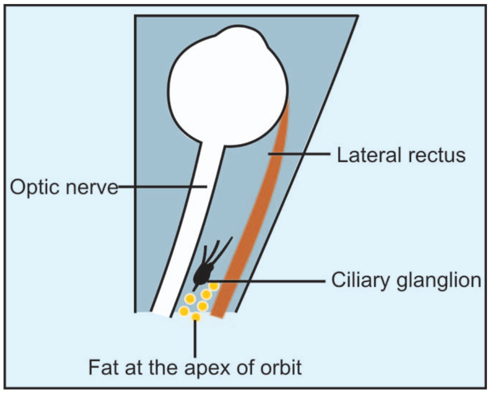
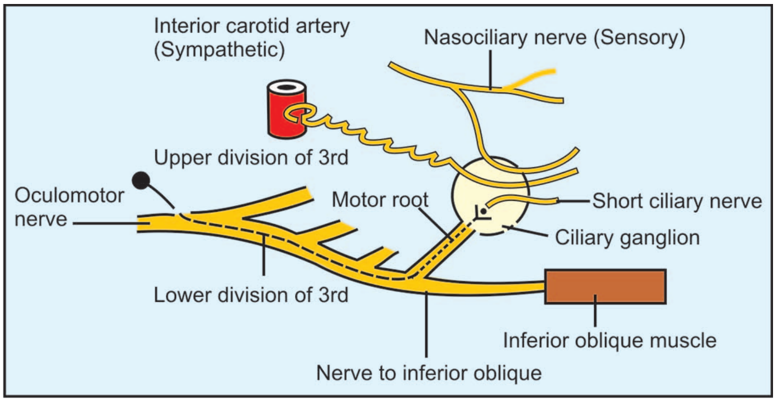



**Figure 179** Showing roots of the ciliary ganglion sensory, sympathetic, motor




**Ophthalmic Artery:** It arises from the internal carotid artery as it leaves the cavernous sinus. It runs through the optic foramen lying inferolateral to the optic nerve in the optic canal. It travels through the subarachnoid space around the optic nerve. Artery first lies below the nerve however gradually pierces the sheath winds the lateral side of the nerve crosses it from above to reach the medial wall of the orbit. During the course in the orbit it lies under the superior oblique muscle. It divides into two branches, the supratrochlear and the dorsal nasal at the anterior part of the orbital cavity.

**Branches :**

1. *Lacrimal artery:* Runs laterally to the lacrimal gland along-with the lacrimal nerve.
2. *Central artery of retina:* It enters the optic nerve gradually in the optic foramen. It is the only source of the blood supply for the retina. It is an end artery.
3. Long and short ciliary arteries arise at the site where the optic nerve enters the sclera. It also gives supraorbital branch.

**Ophthalmic Veins (Figures 180 and 181):** Out of the two ophthalmic veins, superior one is larger in size and it accompanies the ophthalmic artery. Superior ophthalmic vein begins at the anterior part of the orbit and it makes connections with the supra-orbital and supratrochlear veins. Inferior ophthalmic vein runs below the optic nerve. It is connected with the pterygoid venous plexus through the inferior orbital fissure. Both ophthlamic veins open into the cavernous sinus through a common channel or separately.

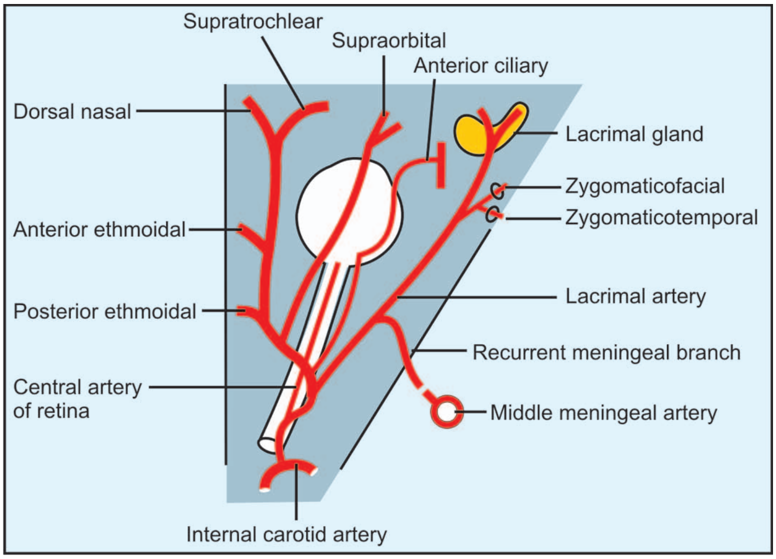



**Figure 180** Showing course and branches of the ophthalmic artery

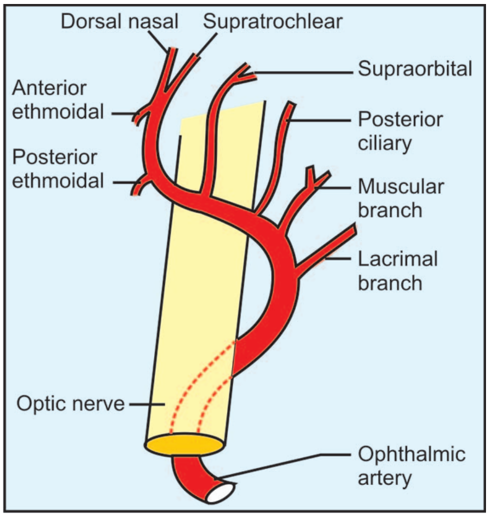


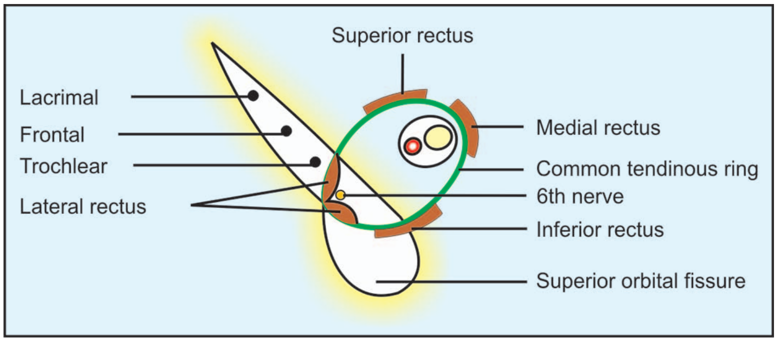

**Figure 181** Showing relations of ophthalmic artery to optic nerve and its branches

**Structures seen in Relation to the Superior Orbital Fissure:** Orbit communicate with the middle cranial fossa through the superior orbital fissure posteriorly. The superior orbital fissure is bounded by the lesser wing of the sphenoid above and the greater wing below. It is broad medially and narrow laterally. Structures-outside the ring are lacrimal frontal and trochlear from lateral to medial side (Liver function test). In addition to this it transmits the meningeal branch of the lacrimal artery and the occasional branch (orbital) of the middle meningeal artery with the superior ophthalmic vein.

**Structures inside the ring (Figure 182):** The two divisions of the oculomotor nerve, with a nasociliary nerve in between occupy the medial part of the common tendinous ring while the abducent, the 6th cranial nerve occupies the interval between two heads

of the lateral rectus muscle in the lateral part of the common tendinous ring. Abducent nerve lies on the medial aspect of the lateral rectus muscle occupying the interval between two heads of the lateral rectus.

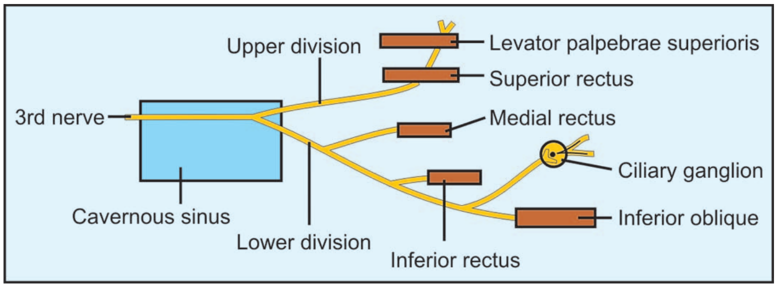
**Figure 182** Showing common tendinus ring and origin of recti two divisions of oculomotor nerve and nasociliary nerve are omitted for clarity




**Oculomotor Nerve:** It has two divisions, superior and the inferior.

**Superior divison (Figure 183):** It pierces the superior rectus muscle, supplies it, and passes to the levator palpebrae superioris muscle.

**Figure 183** Showing oculomotor nerve and its distribution division wise




**Inferior Division:** It divides into three branches, namely the nerve to medial rectus, inferior rectus and the inferior oblique. Nerve to inferior oblique gives parasympathetic (motor) root of the ciliary ganglion.

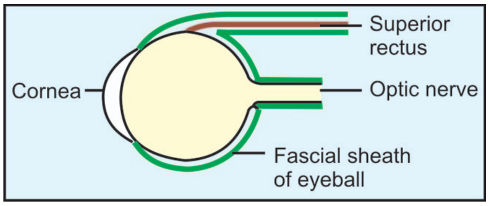
**Abducent Nerve:** Abducent nerve enters the orbit in between the two heads of the lateral rectus and gets exhausted by supplying the ocular surface of the lateral rectus. Lateral rectus abducts the eyeball, hence the name abducent. Paralysis of the abducent nerve leads to medial squint.

**Petrous Apex Syndrome:** Abducent nerve passes under the petrosphenoid ligament. Here it can be compressed, which results in paralysis of the lateral rectus muscle.

**Fascia Bulbi (Figures 184 and 185):** It is a facial socket for 5/6th of the eyeball except the cornea. Internal surface of this sheath is smooth. Between the eyeball and the inner surface of the sheath there is an extensive lymph space. Its anterior attachment is at the sclerocorneal junction, while posteriorly it is attached to the sheath of the optic nerve. Eyeball freely rotates within the fascial sheath.

Edges of the openings through which the recti pass are enforced by slips of the fibrous tissue (Lockwood). Sheaths are attached to orbital wall at various places. These slipis do act as pulleys and thus protect the eyeball from compression during muscular contraction.

**Figure 184** Showing enclosure of eyeball



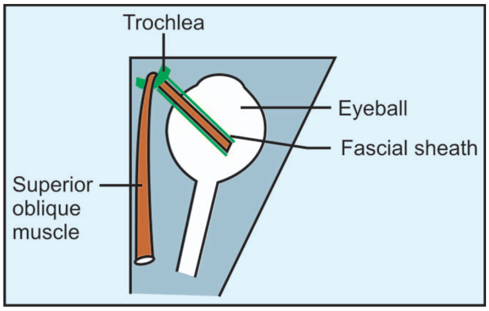



Figure 185 Showing tendon of superior oblique muscle covered with extension of fascial sheath only up to the trochlea

**Suspensory ligament of the eyeball (Figures 186A, B and 187):** It is attached to the zygomatic bone laterally and the lacrimal bone medially. Ends of ligaments are narrow at its lateral and medial attachments while the middle portion is broader. It is placed in the anterior part of the orbit immediately below the eyeball in order to support it like a hammock. (Hammok means bed of canvas or rope mesh).

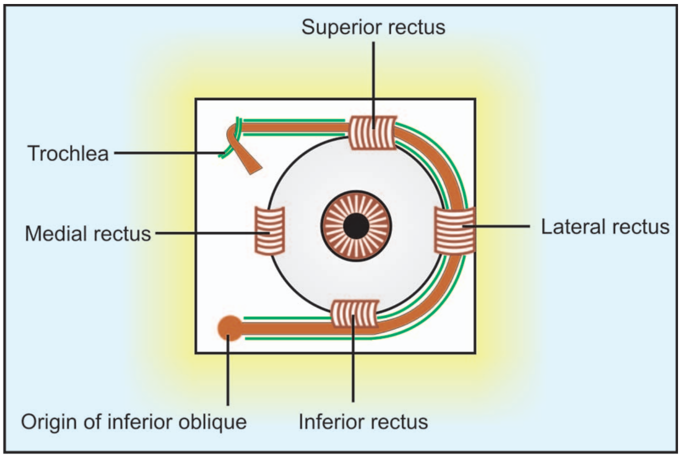



Figure 186 Showing orbit from the front. Please see that the fascial sleeves for the inferior oblique is up to its origin and for the superior oblique it is up to the trochlea

Figure 186A Showing fundoscopic view of retinal vessels

Figure 186B Showing diabetic retinopathy

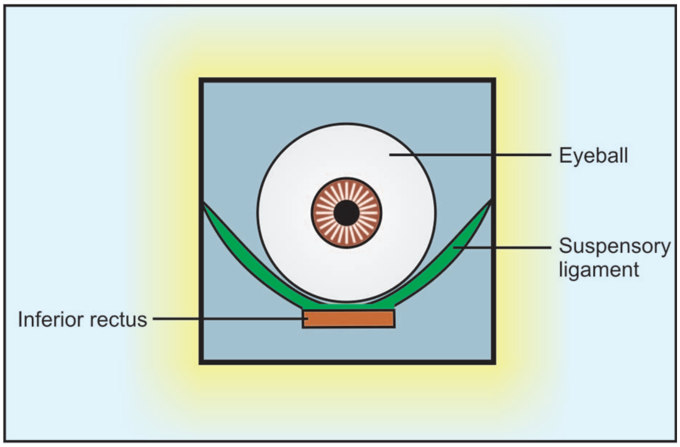



**Figure 187** Showing suspensory ligament (Hammock)

**Lateral and medial cheek ligaments (Figure 188):** They run from the sheath of the lateral rectus to the zygomatic bone and the medial rectus to the lacrimal bone respectively. By virtue of the medial and lateral cheek ligaments, excessive rotation of the eyeball is prevented. Due to the intimate connection of the superior rectus with the levatory palpebrae superioris and the connection of the suspensory ligament of the eyeball with the inferior rectus, actions of the superior and the inferior recti are considerably limited.

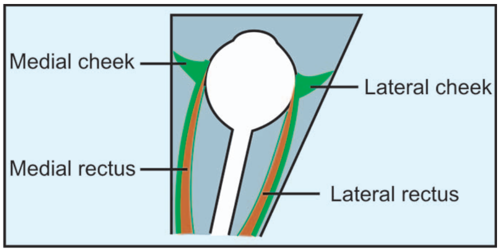



**Figure 188** Showing cheek ligaments

**Ethmoidal sinuses:** They are small air sinuses which lie in between the orbit and the upper part of the nasal cavity. They are present in three groups namely the anterior, middle and the posterior.

**Anterior and middle:** Open into the middle meatus of the nose, while the posterior group opens into the superior meatus of the nose. The sinuses are lined by the vascular mucous membrane having ciliated columnar epithelium, which is continuous with the nasal cavity.

**Figure 188A** Showing pulling eyeball out of orbital socket

Infra orbital and the zygomatic nerves are lying outside the orbital periosteum, while the rest of the orbital contents are within.

**Stability of the Eyeball:** It is interesting to note that the maxilla does not form the basic support of the eyeball. Even if the maxilla is removed, eyeball does not drop down as it is suspended by the suspensary ligament.

Irrespective of the higher degree of mobility of eyeball in the facial socket (fascia bulbi or Tenon's capsule) it does not come out of the orbit or does get pushed inside the orbit. Its posterior displacement is prevented by three important factors. They are:

1. Bony attachment of the recti
2. Orbital fat and the
3. Forward pull of the superior and the inferior oblique muscles.

Caudeo Polo Minto of Brazil pulls his eyeballs 7 mm out of the orbital socket. He is practicing it from the age of 9 years and so far has not lost his eye sight (Photograph from the news) (Figure 188A).

In cases of hyperthyroidism, eyeball is pushed forwards due to the increased volume of the orbital fat fluid and the round cells. Recently it has been attributed to a hormone.

**Lymphatic Drainage of the Orbit:** It is drained into the pre-auricular, parotid lymph nodes and to the antero-superior group of cervical nodes.

# EYEBALL

It has three coats namely (1) sclera and cornea which is the outer fibrous coat, (2) Choroid, cilliary body and iris this is a vascular coat, and the (3) Retina which is inner most coat and is regarded as an expansion of the brain substance of the nerve of the sight (optic nerve).

**Sclera (Figure 189):** It is a non-distendable tough fibrous coat of the eyeball. It maintains the intraocular pressure at the level of 15 to 20 mm of mercury. Anterior part of the sclera is covered with conjucitiva and looks white (white of the eyeball). Sclerocorneal junction is known as limbus. Sinus venosus sclerae is located anterior to the limbus. It is commonly known as canal of Schlemm. The entry of the optic nerve is situated 3 mm to the posterior pole (Figure 189A).

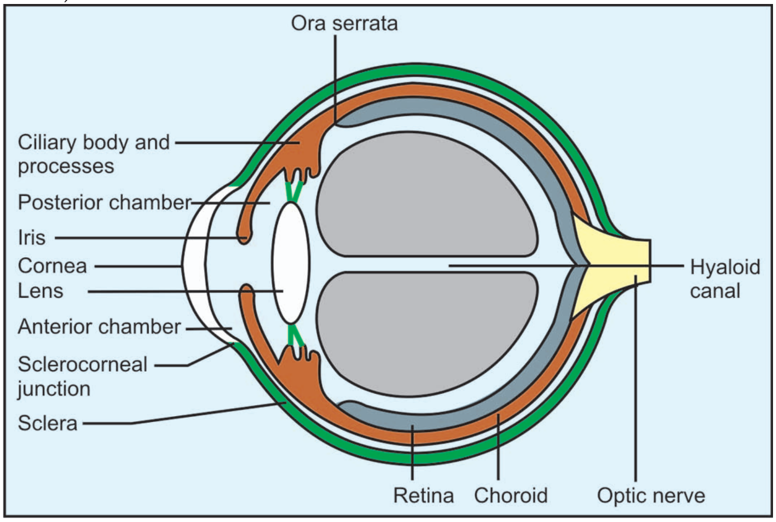



**Figure 189** Showing layers of eyeball ciliary body, iris, lens, anterior and posterior chambers

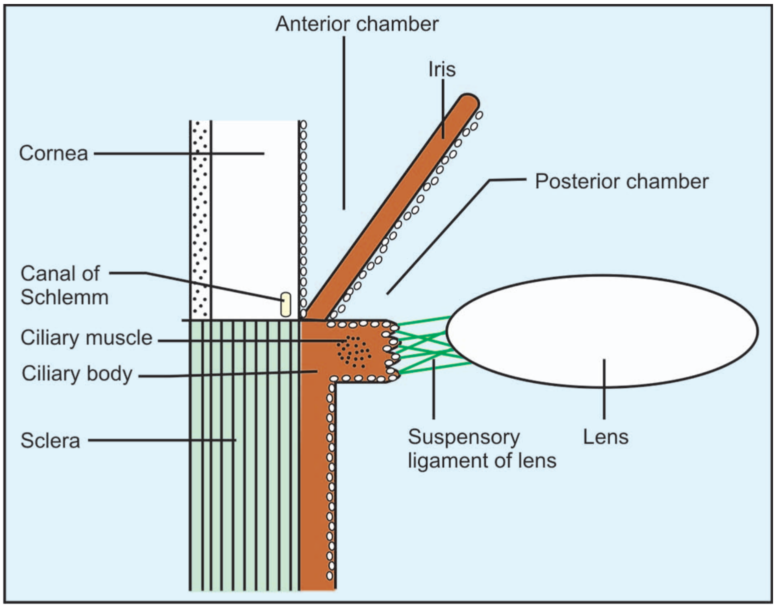



**Figure 189A** Showing sclerocorneal function (highly schematic)

Structures which pierce the sclera.

1. Optic nerve
2. Long ciliary vessels and nerves

3. Short ciliary vessels and nerves
4. Venae vorticosae
5. Anterior ciliary arteries from recti (muscular)
6. Aqueous vein: It drains the aqueous humor from the sinus venosus sclerae into the anterior ciliary veins. These veins pierce the sclera near the limbus.

Sclera is relatively avascular but receives blood supply from anterior ciliary and the long ciliary arteries.

It covers the posterior 5/6 of the eyeball. It is pierced by the fibers of the optic nerve at its entrance. It is known as lamina cribrosa. Due to the increased intraocular pressure (chronic glaucoma), lamina cribrosa fails to sustain the impact of the pressure and as a result it bulges posteriorly. It is described as cupping of the disc. Dural sheath of the optic nerve gets fused with the sclera. It receives, insertions of the ocular muscles and is pierced by the ciliary nerves and the arteries all around the entrance of the optic nerve. Choroid veins (venae vorticosa) are seen piercing this coat a little behind the coronal equator. Sclera though avascular is connected with the ocular conjuctiva by episcleral tissue which is vascular. Rupture of the eyeball usually takes place at the sclerocorneal junction.

**Canal of Schlemm (Sinus Venosus Sclerae):** It is a circular canal situated at the periphery of the anterior chamber. It lies in front of sclero-corneal junction. Aqueous humour enters into the canal and gets drained into the scleral veins.

**Cornea (Figure 190):** It is a transparent and more curved part of the anterior 1/6th of the outer fibrous coat of the eyeball. It is avascular and is nourished by lymph through corneal spaces. Centre part of the cornea gets supply from atmospheric oxygen which gets dissolved in the tears. Avascular cornea is a boon for the surgeon who puts knife on it during surgery. It is supplied by the short cilliary and by some fibers of the long cilliary nerves and is only sensitive to pain. It is a major site of refraction. It is 1.2 mm thick at periphery and 0.5 to 0.6 mm in the centre.

**Microscopic Structure of Cornea:** It is made up of following layers:

1. Statified squamous epithelium.
2. Bowman's capsule (Anterior elastic membrane)
3. *Substantia Propria:* It has dense collagen fibers with corneal spaces, cornial corpuscle are modified fibroblasts.
4. Posterior elastic membrane (Descement membrane) has 3 layers, its inner fibers which run medially towards the iris form ligamentum pectinatum. Middle fibers give origin to the cilliary muscle. Outer fibers join the sclera.
5. Pavement epithelium covers of the back of the cornea (Posterior surface of Descement membrane). It is formed by the simple squomous mesothelium.

**Vascular Coat (Uveal Tract):** It has three parts (1) Choroid, (2) Cilliary body and the (3) Iris.

**Choroid :** It lines the posterior part of the sclera. It is brown in man and black in many animals being pigmented. Anteriorly it ends at the ora serrata, where it merges with the ciliary body. Between choroid and the sclera is the suprachoroid space which contains cilliary vessels and nerves. Attachment of the sclera to the choroid is loose, while the retina and the choroid are firmly united.

**Histological Appearance of Choroid:** It is made up of four layer

1. *Suprachoroid lamina:* It contain collagen, elastic fibres and pigment cells.

2. *Vascular lamina:* It has arteries, veins, and the pigment cells, short ciliary veins form venae corticosae.
3. *Chorio-cappillary lamina*: It is important as it nourishes the rods and cones by diffusion.
4. *Basal lamina* (Lamina vitrea or the membrane of Bruch): It is transparent, structureless thin layer almost fixed to the outer pigmented layer of retina.

**Ciliary Body:** It is the thickened part of the uveal tract situated posterior to corneal limbus. Posteriorly it is continuous with the choroid and anteriorly with the iris. It gives attachment to the lens and helps in accommodation for near vision. It is applied to the inner surface of the scleral spur. It is thick in front and thin behind. It has ciliary muscles and ciliary processes.

**Ciliary Muscle:** It consists of smooth or unstriated muscles. It helps in focusing the lens for the near vision. The cilliary muscles forms the intrinsic muscle of the eyeball. It is supplied by parasympathetic element from third cranial nerve. When the ciliary muscle contracts the suspensory ligaments are relaxed and the lense buldges anteriorly.

**Iris:** It is attached to the middle of the anterior surface of the ciliary body. Iris is perforated centrally by the pupil, which controls the amount of light entering the eyeball. Size of the pupil is controlled by the circular and the radial fibers. Circular fibers are known as the sphincter pupillae and radial fibers are known as the dialator pupillae. Circular fibres are supplied by parasympathetic and the radial fibres are supplied by sympathetic. Sympathetic stimulation dialates the pupil and the parasympathetic constrict the pupil.

**Vascular Pattern of the Iris (Figure 190):** It is made of blood vessels and the loose connective tissues between them. Two long ciliary arteries enter the back of the sclera and run forwards in the suprachoroidal space. Anteriorly they are joined by the anterior ciliary arteries which arise from the branches to the recti to form the major circle of the iris. Vessels pass radially towards the pupillary margin where they form a minor circle of the iris.

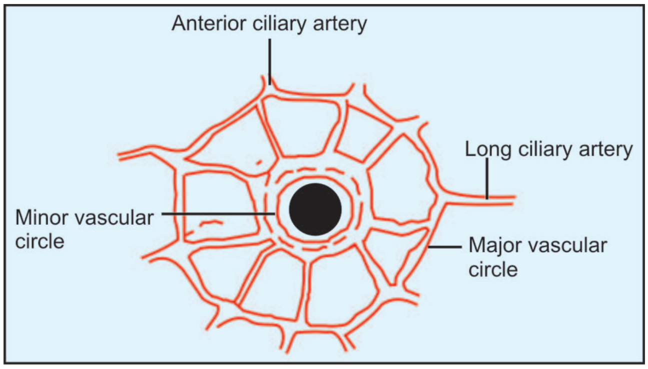



**Figure 190** Showing vascular pattern of the iris

**Retina (Figure 191):** It is the innermost coat of the neural layer of the eyeball. The neural layer is sensitive to light. It ends anteriorly at the ora serrata. At the entrance of the optic nerve the opening is circular, pale and having a diameter of 1.5 mm. It has no rods or cones therefore not sensitive to light (Blind spot). Depression of the optic cup is known as physiological cupping. Fovea centralis has only the cones which responds to bright light and colours. Cones contain idopsin. It is sensitive to bright light and colours. This is known as photopic vision. Rods contain visual purple and responds to the dim light and black and white colours (Scotopic vision).

Retinal photoreceptors convert light energy into the electrical and impulses are carried by the axons of the ganglion cells of the retina.

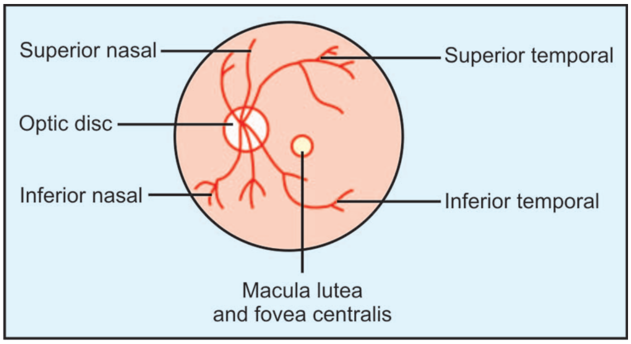



**Figure 191** Showing distribution of central artery of retina as seen in fundus oculi

**Microscopic structures of the retina:** Outer layer is pigmented and is firmly attached to the vascular choroids, immediately adjacent to this is the layer of rods and cones. It is loosely attached to the pigment layer. During the retinal detachment there is separation of the layer of the rods and cones from that of the pigmented layer. There are three neurones interposed between the retina and the cortex. (1) First neurone is the bipolar cell of the retina. (2) Second neurone is a ganglion cell of the retina. Axon of these cells pass to the lateral geniculate body, (3) After relay here, third neurone starts and reaches the sensory cortex through the internal capsule (Figures 191A and B).

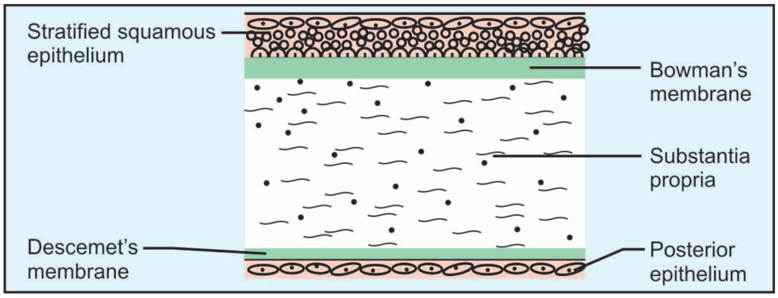



**Figure 191A** Showing structue of cornea

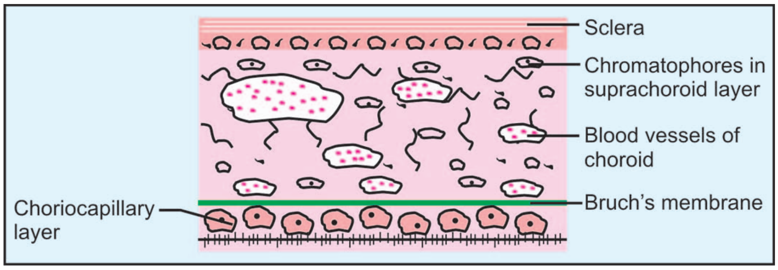



**Figure 191B** Showing structure of choroid

**Retina has the following layers (Figure 192):**

1. Pigment layer – is outer most.
2. Layer of rods and cones. Nos. of cones become lesser and lesser towards the periphery.
3. External limiting membrane.
4. Outer nuclear layer.
5. Outer molecular layer.
6. Inner nuclear layer.
7. Inner molecular layer.
8. Ganglion cell layer – It contains large cell bodies and form second order of neurones.
9. Nerve fiber layer – it contains the axons of the ganglion cells.
10. Internal limiting membrane – It lies between the retina and the vitreous. Attached to it are the expanded bases of the fibers of Muller.

**Blood Supply of Retina (Figure 191 and 192):** Central artery of the retina divides into the upper and the lower divisions at the optic disc. They give temporal and nasal branches. They are the end arteries. Central artery of retina supplies only the bipolar cells and the ganglion cells. Layers of rods and cones and the outer nuclear layer are supplied by diffusion from the capillaries of the choroidal layer. Retinal veins come with the branches of the central artery and leave the optic disc. Arteries enter and veins leave at the site of optic nerve entrance. They emerge from the nerve and its coverings to join the superior ophthalmic vein.

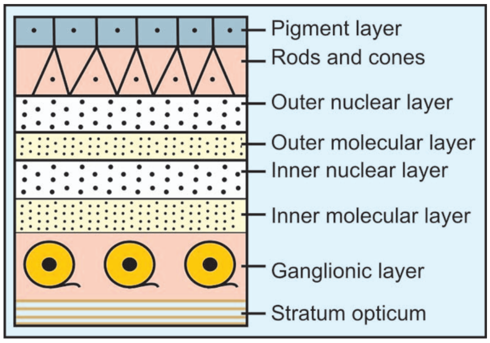



**Figure 192** Showing layers of retina (highly schematic)

**Development of Eyeball (Figures 193 and 194):** It developes from the optic vesicle, with stalk appearing as a protrusion of the diencephalon. It soon gets invaginated, to form the optic cup, which consists of the two layers. Outer layer forms the pigment layer and the inner layer differentiates into the rest of layers of retina.

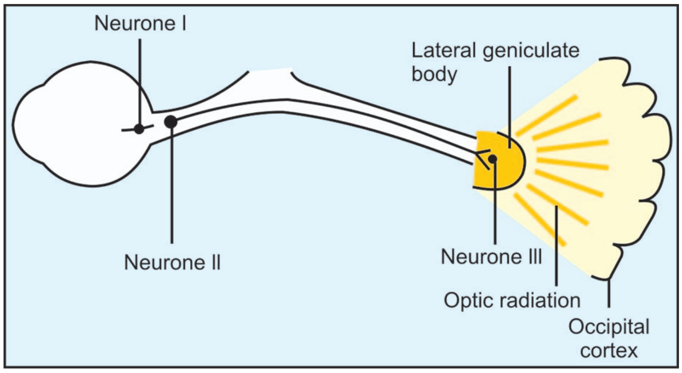



**Figure 193** Showing neurones along the visual pathway

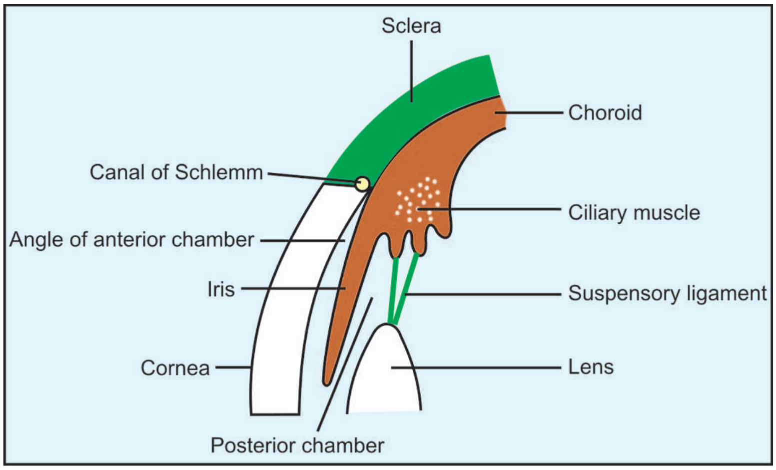



**Figure 194** Showing structures at sclerocorneal junction

Eyeball develops from three sources:

1. Surface ectoderm
2. Neuroectoderm
3. Mesenchyme

In the fourth week of intrauterine life optic vessicle appears. It induces the surface ectoderm to form lense placode. Lense placode gets converted into lense vesicle and gets detached from the surface and is cought by the optic cup like a ball. Inferiorly there is a defect in the optic cup and the stalk it is known as choroid fissure. It gives passage to hyloid artery which runs to the back of the lense and supplies it. Persistence of the choroid fissure is known as Coloboma. Outer layer of the cup gives origin to the pigment layer, while the inner to the neural. Myelination of the optic nerve occurs after birth. The myelin sheath of the optic nerve is derived from oligodendroglia. Central artery of retina and the vein are derived from the hyloid artery and the vein. During development, lense has rich blood supply from the hyloid and anterior choroidal arteries through its capsule which disappear before birth.

**Clinical:**

1. Congenital cataract: It occurs due to viral infection like rubella and malnutrition. It is also seen in Down syndrome.
2. Absence of lense (Aphakia):
3. Non-disintegration of pupillary membrane before birth.
4. Coloboma due to persistence of choroidal fissure.

**Down Syndrome:** It is associated with three copies of 21 cromosomes. There is marked mental retardation, slopping of the forehead, low ears and short broad hands with single palmar crease with changes in the brain.

**Lens:** It is a biconvex body enclosed in a transparent elastic capsule. Its anterior surface is slightly less convex than the posterior which is in contact with the vitreous. Anterior surface is in contact with the pupillary margin of the iris. It is attached at the periphery to the suspensory ligaments (Zonule of Zinn) to the ciliary processes. Its diameter is 1 cm, it has transparent structureless elastic capsule. Axis of the lens runs between the anterior and posterior poles of the lens. Equator is at the periphery. Lense develops in the four to six weeks of intrauterine life. If the mother is exposed to viral infections like German measels before seventh week the child may develop congenital cataract. The cells of the posterior wall of the lense elongate rapidly. They are filled with crystal lines which help them in making it transparent. These fibres are known as primary lens fibres. Due to mitotic division of the anterior epithelial cells the new lense fibres (secondary) are formed. This process of formation of secondary lense fibres continues through out the life. Older fibres are pushed into centre while the new one fibres remain at the periphery. Older fibres form the hard core of the lens and at the periphery is the soft coat. The mesenchyme infront of the lens forms pupillary membrane which disappears during eighth week of intrauterine life. Lens has a vascular capsule which is supplied by the hyloid and anterior choroidal arteries. The vascular capsule of the lens disappears before birth.

**Suspensory Ligament (Zonule of Zinn):** Suspensory ligament is attached to the cilliary processes and the front or even the back of the periphery of the lens. During contraction of the cilliary muscle the anterior surface of the lens bulges forwards. Normally lens is kept flat under tension, during the position of the rest.

**Anterior Chamber:** Anterior chamber is the space between posterior surface of cornea and anterior surface of the iris. It is 3 mm deep centrally. Aqueous humor enters the spaces of Fontana from where it is drained into the canal of Schemm. If the angle is obliterated the drainage of the aqueous is hampered leading to increased intraocular tension (Glaucoma).

**Posterior Chamber:** It is bounded anteriorly by the iris and posteriorly by the lens and the suspensory ligament.

**Development of Lens:** Ectoderm overlying the optic vesicle gets thickened to form the lens placode. Development of the lens placode depends upon the induction power of the optic vesicle. At 5 mm stage lens placode gets depressed to form the lens vesicle. Surrounding mesoderm gives rise to the lens capsule. Posterior part of the capsule is vascularised by the hyloid artery and its anterior part by the anular artery. Normally this vascularity vanishes before birth. It may persist in certain form of congenital cataract.

**More about the Lens:** Lens can change its dioptric power which is only 15. Power of two diopters means focal length of 1/2 meter of the lens. Blockage of the irido-corneal angle leads to increased intraoccular pressure, pathological cupping of the optic disc leading to the retinal atrophy and the blindness (Glaucoma). Aqueous humor contains glucose, amino acids and vitamin C. It gives nourishment to the cornea.

**Capsule:** Lens has transperent elastic and structureless capsule. Anterior surface of the lense is covered with epithelial cells having single layer of cubical cells. At the periphery, cells elongate to form the fibres of the lens. They are concentrically arranged.

**Aqueous Humor:** It is placed between the cornea and the lens. It is produced by the ciliary processes in the posterior chamber. It enters the anterior chamber through the pupillary aperture and enter the spaces of the Fontana, and drain into the canal of Schlemm.

# DEEP PART OF THE NECK

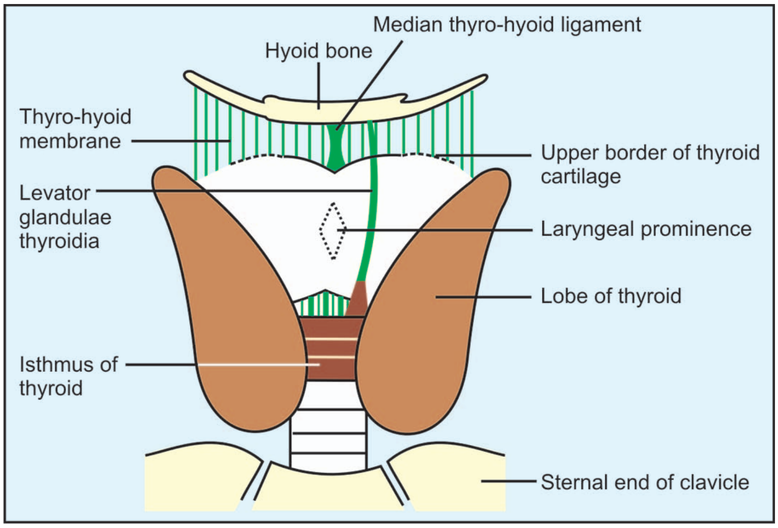
## Thyroid Gland

Thyroid gland is one of the most important endocrine organs.

**Situation:** Thyroid gland is situated in front and of the side of neck in relation with the trachea and the larynx.

**Shape and the parts (Figure 195):** It has two parts in the form of lateral lobes which are connected by means of an isthmus which overlies the 2nd, 3rd and 4th tracheal rings. Each lobe is conical in shape with its base directed downwards and the apex upwards. Lower end of the thyroid lobe reaches the medial end of the clavicle and the upper pole is reaches superior border of thyroid cartilage. Its further upward extension is prevented by the attachment of the pretracheal fascia and the sterno thyroid muscle to the oblique line of the thyroid cartilage.

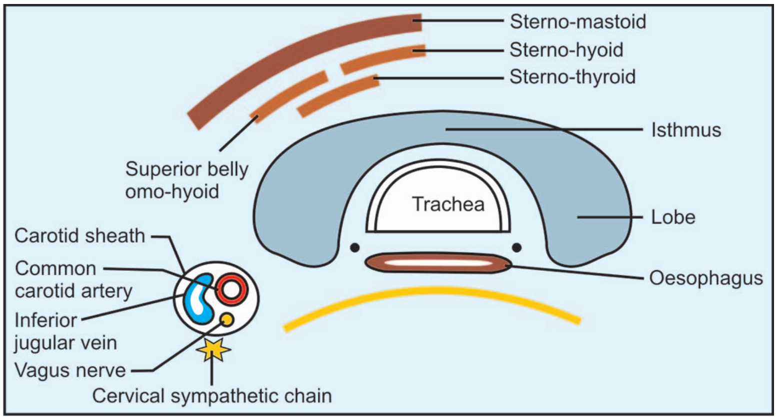
**Figure 195** Showing anterior view of thyroid gland




**Surfaces (Figure 196):** Each lobe has 3 surfaces:

1. Antero-lateral
2. Postero-lateral and
3. Deep or the medial surface.

**Figure 196** Showing horizontal section of thyroid gland at the level of isthmus



**Borders:** Separating the antero-lateral and the posterolateral surfaces lies the broad round posterior border. Superior and inferior thyroid arteries anastomose along the posterior border.

**Pyramidal Lobe:** When present it projects upwards from the isthmus usually to the left of the median plane. It is connected with the hyoid bone by the levator glandulae thyroidae. Levator glandular thyroidea is a fibromuscular band attaching the apex of pyramidal lobe to the hyoid bone.

**Relations (Figures 197 and 198):**

1. Antero-lateral surface :
   - i. Sternomastoid.
   - ii. Sternohyoid
   - iii. Omohyoid and
   - iv. Sternothyroid muscles.
2. Posterolateral surface:
   - i. Posterolateral surface is related to the carotid sheath, which contains common carotid artery,
   - ii. internal jugular vein
   - iii. Vagus nerve.
   - iv. Sympathetic chain form the posterior relation of the carotid sheath.
3. Deep surface:
   It is related with
   - i. Two cartilages,
   - ii. Two tubes,
   - iii. Two muscles
   - iv. Two nerves
   - v. Two organs.

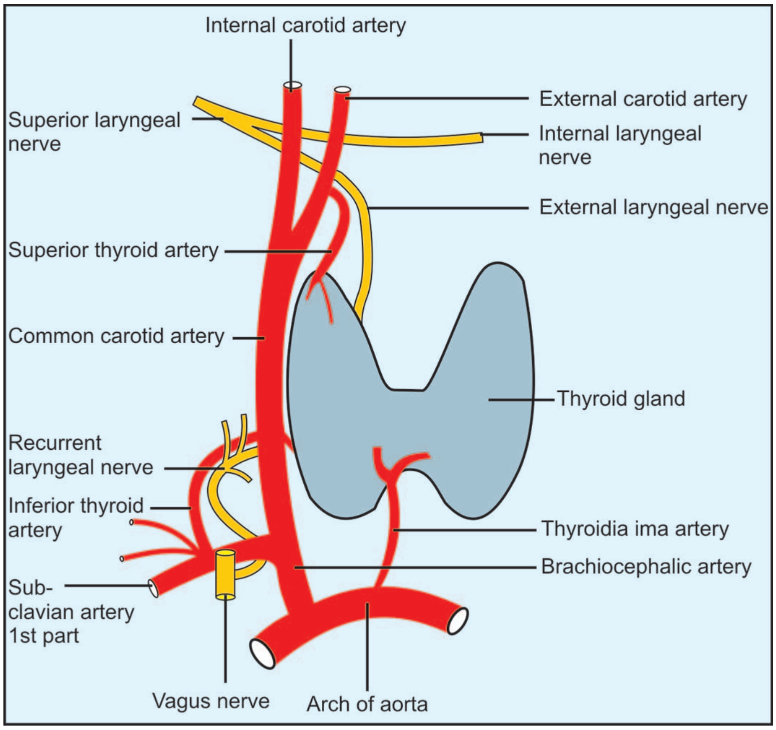



**Figure 197** Showing blood supply of thyroid gland. Please note the recurrent laryngeal nerve is closed to the inferior thyroid artery near the gland and the external laryngeal nerve is away from the superior thyroid artery near the gland

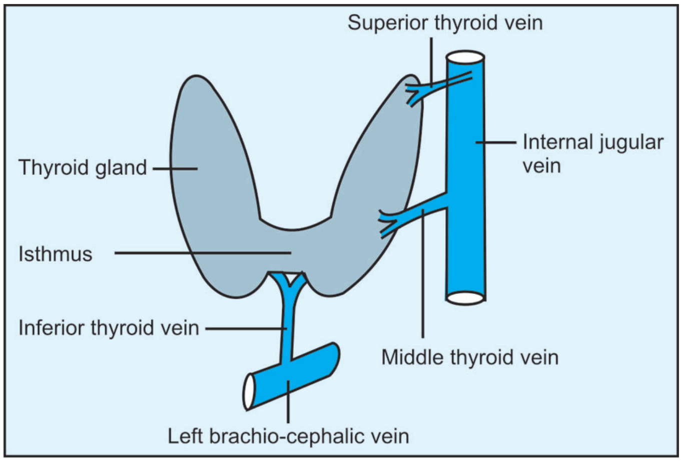



**Figure 198** Showing thyroid veins

*Two cartilages:*

i. Thyroid
ii. Cricoid.

*Two muscles :*

i. Cricothyroid
ii. Inferior constrictor.

*Two tubes:*

i. Oesophagus
ii. Trachea.

*Two nerves:*

i. External laryngeal and
ii. Recurrent laryngeal nerves.

*Two organs (Figure 199):*

i. Larynx
ii. Pharynx.

The last two are conveniently forgotten.

Along the posterior border is an anastomosis of the superior and the inferior thyroid arteries. Parathyroid gland are situated on this border.

**Capsule:** Thyroid gland has capsules like the prostate, the fascial fibers. Sheath of the thyroid gland is weak on the posterior aspect. Fibrous capsule is of its own while the fascial is provided by the pretracheal layers of fascia. Venous plexus lies under the fibrous capsule and not between the fascial and the fibrous as seen in the prostate.

**Blood Supply:** Thyroid gland has rich blood supply. It is supplied by the superior thyroid and inferior thyroid arteries. Superior thyroid artery arises from the external carotid artery in the carotid triangle while the inferior thyroid arises from first part of the subclavian artery as one of the branches of the thyrocervical trunk.

Superior thyroid artery supplies the upper one-third of the lobe and the upper half of the isthmus. Inferior thyroid artery supplies the lower two-thirds of the lobe and the lower half of the isthmus. In addition to these, isthmus gets its blood supply from the thyroidea ima artery when present. It may arise either from the innominate, left common carotid or from the aorta directly. There is a good amount of anastomosis between the thyroid arteries across the midline.

*Note:* Even if all the thyroid arteries are ligated yet the thyroid gland bleed, as it gets additional blood supply from laryngeal, pharyngeal, tracheal and the oesophageal branches.

**Venous Drainage:** They are three:

1. Superior thyroid vein ends in the internal jugular vein or the common facial vein.
2. Middle thyroid vein-ends into the internal jugular vein at the level of cricoid.
3. Inferior thyroid vein begins at the isthmus, gets some tributaries from the lower poles, runs on the trachea and joins the left bracheo-cephalic vein in the superior mediastinum. Many time the inferior veins are two.

**Lymphatic Drainage:** Lymphatics of the thyroid gland are important. Some authors believe that the colloid secretion of the gland is removed by the lymphatics. Lymph vessels pass to the lymph nodes on the surface of the gland, to paratracheal group and the deep cervical group of lymph nodes. Sometimes one of the lymphatic channel may pass from the upper pole to the retro-pharyngeal node. One of the lymphatic channels may descend into the thorax to join the mediastinal lymph nodes, along the thyro-thymic ligament. Some of the lymphatics end in the thoracic duct and even in the internal jugular vein directly.

**Nerve Supply:** Thyroid gland is supplied by the superior, middle and the inferior cervical ganglia of the cervical sympathetic chain.

**Histology:** Thyroid gland has a thin connective tissue capsule and the interior of the glandular substance is divided into masses of varying sizes. It is interesting to note that the follicle is devoid of basement membrane. Cells are seen lining the follicle and they are in direct contact with the connective tissue and the blood vessels. When the follicle is full of colloid material, cells are flattened and when the colloid material is less, the cells are of low columnar type. Thyroxin comes out of the follicles in between the cells and is absorbed by the blood vessels. Para-follicular cells or the 'C' cells are seen near the follicles.

**Development:** Thyroid gland develops in the 4th week as an endodermal down growth from the floor of the primitive pharynx at the future site of foramen, caecum in the form of median thyroid diverticulum which descends into the neck. It passes infront below and behind the body of the hyoid and goes lower down (Figure 199A). It becomes bilobed to form the lobes of the thyroid gland. Para-follicular cells or 'C' cells are derived from the neural crest. This downgrowth grows caudally and becomes bilobed. It looses its lumen. It still remains to be decided finally whether the 4th pouch contributes to the formation of the lobes or not.

**Clinical:** Enlargement of the thyroid gland is known as goiter. It presses on the trachea and the recurrent laryngeal nerve. Pressure on the trachea causes cough and pressure on the recurrent laryngeal results in hoarsness of voice. During partial excision of the thyroid, posterior part of the lobe is not removed due to the risk of removing the parathyroid glands.

Normally thyroglossal duct disappears, in case it persist it gives rise to thyroglossal cyst or fistula.

Cancer of the thyroid gland erodes the trachea, oesophagus or the carotid sheath. Erosion of the carotid vessels is dangerous as it results in severe haemorrhage.

Involvement of the cervical sympathetic chain produces 'Horner's syndrome.

Thyroid swellings move with deglutition because of pretracheal fascia which forms the facial covering of the gland and suspensory ligament of

Berry which is a fibrous band running from the cricoid to the isthamus. I am really puzzled when I see the causes of movement of upward thyroid in which lavator glandular thyroid is singularly missing.

During ligation of the inferior thyroid artery all possible precautions should be taken to avoid injury to the recurrent laryngeal nerve, which lies in close proximity with the artery near the gland; so be away from the gland. Superior thyroid artery is away from the external laryngeal nerve near the gland hence the artery should be ligated near the gland.

**Parathyroid Glands (Figure 199):** They are of the size of small peas, and are arranged in the superior and inferior pairs. Superior pair lies at the middle of the posterior border thyroid gland and the inferior border at the lower pole of the gland. Inferior parathyroids may lie within the fascial sheath, or in the substance of the thyroid gland. Inferior thyroid artery gives twigs to both the glands, superior and the inferior (Figure 199). In fresh states their colour is yellowish brown which helps its identification. The inferior parathyroid is close to the inferior thyroid veins.

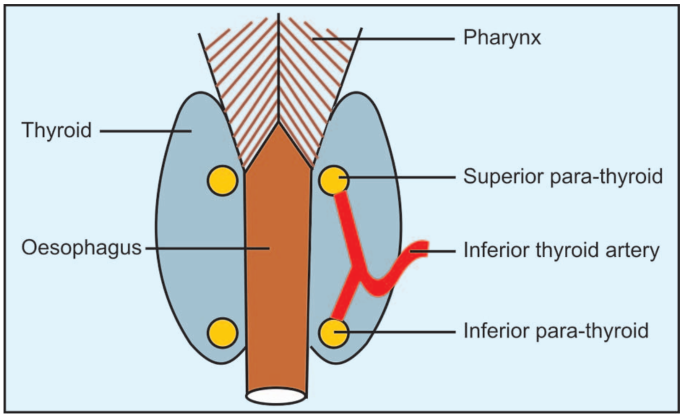



**Figure 199** Showing positions of para-thyroid gland (posterior view)

**Histology:** Parathyroid has thin capsule made-up of connective tissue. Numerous fibrous septae run into the interior of the gland to divide it into lobules. Cells are arranged in cords or columns around the sinusoids. Chief cells or the principal cells are of three types

1. Dark principal cells,
2. Light principal cells and
3. Clear principal cells which do not get readily and easily stained. Parathyroid hormone is liberated by the principal cells. Oxyphil (eosinophil) cells make their appearance at the age of 7 to 8 years. These cells are larger with more amount of cytoplasm, which is granular and stains deeply with eosin.

**Development of Parathyroid (Figure 199A):** They are endodermal in origin. Superior parathyroids develops from the 4th pharyngeal pouch and the inferior parathyroids develop from the 3rd pouch along with the thymus. As the thymus descends, inferior parathyroid too come down and occupy lower position. (Remember thymus for three)

**Clinical:** Various locations of the inferior parathyroid are surgically important.

If it lies within the fascial sheath of the thyroid then the tumour has tendency to descend downwards along the inferior thyroid veins, in front of the trachea into the superior mediastinum. If it lies behind and outside the fascial sheath of the thyroid the tumour passes downwards and backwards, behind the oesophagus in the posterior mediastinum.

**Clinical:** *Lingual thyroid*— On examination of the oral cavity a rounded swelling is seen at the posterior one third of the tongue at the site of foramen caecum.

*Complications of the lingual thyroid:*

1. Dysphagia
2. Difficulty in speech
3. Haemorrhage

Think twice before deciding its removal as it could be only functioning thyroid tissue. Removal is followed by giving L-thyroxin to the patient for the whole life.

**Thyroglossal Cyst:** It arises from the thyroglossal duct and lies in the mid-line of the neck. It moves with protrusion of the tongue and swallowing.

It should be excised for the fear of infection as the wall of the cyst is studded with lymphatic tissue, which is connected with the cervical lymph nodes.

In case it is incised thinking it to be an abscess, it ends in formation of the thyroglossal fistula.

Due to the close relation of the fistulous tract with the body of the hyoid bone the tract is removed with the body of the hyoid. (Sistrunk's operation).

**Cretinism:** It occurs due to non-or poor development of the thyroid. Patient looks pale, puffy, stunted, potbellied with umbilical hernia. Patient is mentally retarded, has a protruding tongue and supra-clavicular pads of fat.

**Goiter:** Enlargement of the thyroid is known as goiter. It could be simple or toxic. Goiter can be prevented by consuming iodised salt.

**Investigations:** T3, T4, TSH level in blood.

X-ray of the chest for evidence of retrosternal goiter. It also shows the tracheal deviation and compression.

CT/ MRI are preferred investigations as it gives detailes of the anatomy of the thyroid swelling.

**Isotopes Scan:** Dye is picked up by the functioning tissue and not by the nonfunctioning.

**Retrosternal Goiter:** It is rarely congenital. It is commonly seen in persons whith short neck and powerful infrahyoid muscles (Sternohyoid, sternothyroid) which push the thyroid swelling into the superior mediastinum. It is actively held by the negative pressure in the thorax.

*Clinical effects of retrosternal goiter:*

They are as under:

| | | |
|---|---|---|
| Oesophagus | — | Dysphagia |
| Trachea | — | Cough |
| Recurrent laryngeal nerve | — | Hoarsness of voice |
| Prominent veins at the thoracic inlet | — | Which could be due to obstruction of the superior venacava, apart from the compression of the retrosternal goiter. |

*Note:* Initially cases of retrosternal goiter make rounds of asthma clinics due to non-yielding persistent cough accompanying by the laryngeal stridor.

**Hyperthyroidism (Graves' Disease):** It is due to the hyper functioning of the thyroid gland which leads to high T3 T4 level and low TSH level. The concentration of the T3 and T4 which depresses the anterior lobe of the pituitary resulting in low TSH.

**Clinical:** Patient has palpitation

Loss of weight

Tiredness

Excessive apetite.

**Signs:** Trachycardia, exophthalamos, proximal muscle myopathy as seen in cases who are on steroid for long with a heavy dose.

**Exopthalmos** It is due to retro-bulber collection of fluid and cells. Lid-lag is due to the anatomical reason as the upper lid is supplied by the sympathetic fibers, there is a wide palpable fissure and the conjunctiva is seen easily.

**Myxodema:** Myxodema with mild symptoms are missed or diagnosed late. Mild thyroid deficiency is the cause.

**Clinical:** Cold, dry, thick skin, weight gain, lithargy, carpal tunnel syndrome. Patient of Myxiodema can go into comma and die.

**Carcinoma of Thyroid:** Carcinoma of thyroid mostly spread through blood to the bones. The lymphatic spread involves the deep cervical lymph nodes of the same side.

**Occult Carcinoma of Thyroid:** In this case the thyroid is normal, however the fracture of humerus occurs due to metastasis of thyroid cancerous tissue, causing pathological fracture. Thyroid looks normal and no nodule is felt.

**Hyperparathy-Roidism:** Presents as tetany with carpo-pedal spasm. Tapping of the facial nerve causes twitching at the angle of mouth, ala of the nose and the lids. Chvostek's sign.

Hypothyroidism is seen after the operation of radical thyroidectomy. Classical presentation of hypoparathyroidism is described as bones, renal stones, abdominal growns and the Psychic-mons.

| | | |
|---|---|---|
| Bone | - | Decalcified |
| Kidney | - | Stones |
| Abdomen | - | Pain, nausea and vomiting. |
| Psychic-mons | - | Personality change. |

**Trachea:** Trachea begins at the level of the 6th cervical vertebra (cricoid cartilage) and runs downwards to enter the superior mediastinum, through the thoracic inlet. Anteriorly it is covered by the isthmus of the thyroid gland which lies on the 2nd, 3rd and 4th rings. Below the isthmus it is related to the inferior thyroid vein or veins. It is to be remembered that in case of the children left bracheo-cephalic vein is situated at higher level in the root of the neck. Trachea is superficially covered with skin, superficial fascia, investigating and pretracheal layers of the deep cervical fascia, with the anterior jugular veins and a jugular arch. Laterally it is related to the lobes of the thyroid gland and carotid sheaths (which contains common carotid artery, internal jugular vein and the vagus nerve). Groove between the trachea and the oesophagus contains the recurrent laryngeal nerves.

**Oesophagus:** Oesophagus is a muscular tube having length of about 10 inches (25 cm). (There are ten alphabets in the word 'oesophagus'). It begins in the neck at the level of the 6th cervical vertebra (level of the cricoid cartilage), where pharynx ends and the oesophagus begins. It runs vertically downwards and follows the curves of the vertebral column. At the beginning it lies in the mid-line, but shifts to the left gradually at the root of the neck. It regains the midline position again at the level of the 5th thoracic vertebra which it maintains till it reaches the level of the 7th thoracic level. At the level of the 7th thoracic goes again to the left.

**Relations:**

**Anterior**

- Trachea.
- Recurrent laryngeal nerve between trachea and the oesophagus.
- Isthmus of thyroid over second, third and the fourth tracheal rings.

**Posterior (Figure 199A)**

- Vertebral column
- Anterior longitudinal ligament.
- Longus cervicis muscle (upto lower border of the 3rd thoracic vertebra).
- Prevertebral fascia up to the lower border of the 3rd thoracic vertebra.
- Retro-oesophageal subclavian artery when present (Figure 199B).

**Figure 199A** Showing development of thyroid gland

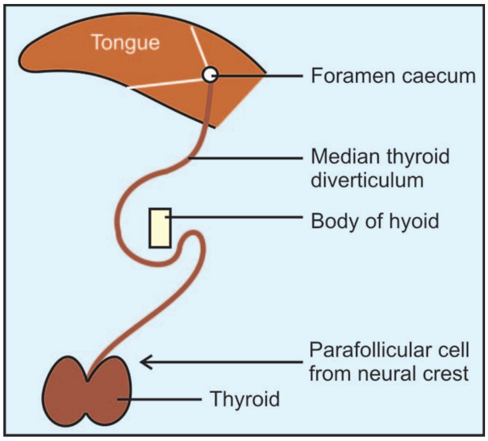
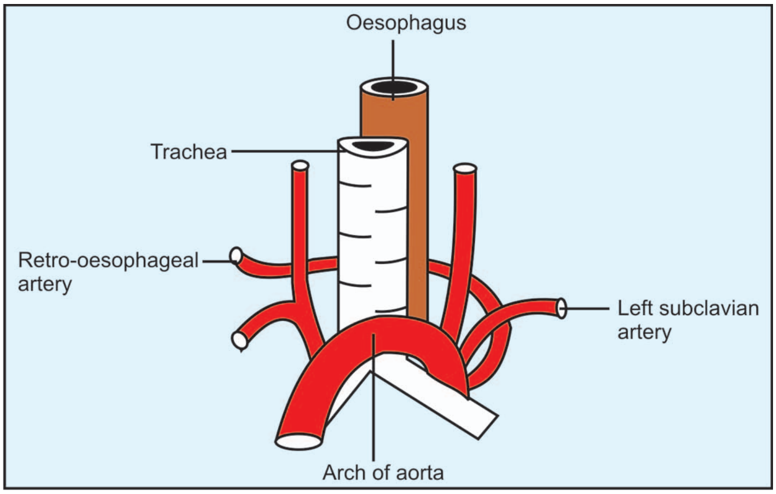



**Figure 199B** Showing retro-eosophageal artery (Dysphagia Lusoria)




**Lateral :**

- Common carotid artery.
- Posterior part of the lateral lobe of thyroid.

Lateral relations in the lower part of the neck are slightly different. Oesophagus projects to the left making more intimate contact with left carotid sheath and the thyroid gland. Thoracic duct ascends for a short distance along the left border of the oesophagus.

**Structure :** It is made up of the following coats,

1. Fibrous coat
2. *Muscular coat:* It consists of two layers longitudinal and circular. Longitudinal coat is situated outside and the circular is inside.
3. *Submucous coat:* Contains blood vessels and nerves and mucous glands.
4. *Mucous coat:* Shows longitudinal folds and is lined by the stratified squamous epithelium. However at the lower end of the oesophagus it is replaced by the simple columnar epithelium.

It is made up of stratified epithelium, layer of connective tissue and the muscularis mucosae. At the gastro-oesophageal junction stratified epithelium is replaced by simple columnar epithelium.

**Oesophageal Glands:** Are compound racemose glands of mucous type. They are present in the submucous coat.

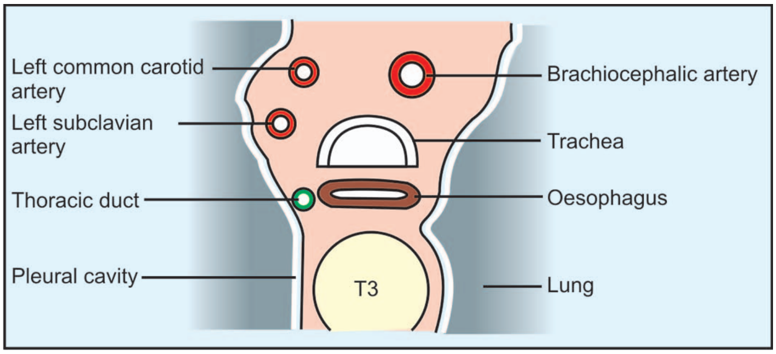
**Blood Supply:** Cervical part of the oesophagus is supplied by the branches of the inferior thyroid arteries.

**Venous Drainage:** Drains into the inferior thyroid veins.

**Nerve Supply:** It is supplied by the branches of the recurrent laryngeal nerves and the cervical sympathetic trunks.

**Brachiocephalic Artery (Figure 200):** Arises from the arch of the aorta and runs upwards and to the right behind the upper margin of the sternoclavicular joint where it divides into the right common carotid and the right subclavian arteries. Only a small portion of brachiocephalic artery comes in the region of the neck.

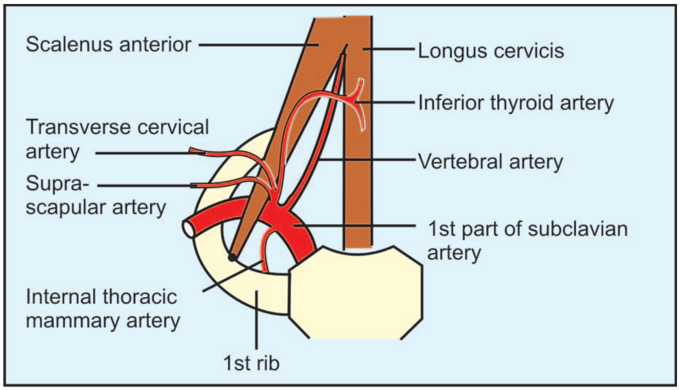
**Figure 200** Showing relations of brachiocephalic artery




*Relations of the bracheo-cephalic artery:*
*Anterior :* Sternohyoid, sternothyroid muscles and the sternoclavicular joint.
*Medial:* Medially it is related to the trachea.
*Laterally:* Is the right brachiocephalic vein.
*Posterior :* Pleura, and the vagus nerve.

**Subclavian Artery (Figure 201):** On the right side it arises as one of the two terminal branches of the brachiocephalic artery behind the right sternoclavicular joint. On the left it arises from the arch of the aorta and ascends upwards and to the left to the back of the left sternoclavicular joint. It crosses the root of the neck by taking an arched course. During this part of its course it lies in front of the cervical pleura, little below its apex. Beyond the outer border of the first rib it is known as axillary artery. As is passes under cover of the scalenus anterior muscle, it is divided into three parts.

**Figure 201** Showing 1st part of right subclavian artery and branches




*First part:* Extends from the origin to the medial border of the scalenus anterior muscle.
*Second part:* Lies behind the scalenus anterior.
*Third part:* Extends from the lateral border of the scalenus anterior to the outer border of the first rib.

**First Part of Right Subclavian Artery: Anterior Relations (Figure 202):** Extends obliquely upwards and laterally and reaches the medial border of the scalenus anterior muscle. It lies about 1.25 cm above the clavicle.

i. Skin
ii. Superficial fascia
iii. Platysma
iv. Deep fascia
v. Sternomastoid

vi. Sternohyoid
vii. Sternothyroid muscles
viii. Internal jugular vein
ix. Vertebral veins lie in front
x. Common carotid artery lies in front of the lower part of the subclavian artery
xi. Vagus nerve
xii. Loop of the sympathetic (Ansa subclavia)
xiii. Cardiac branches of the vagus

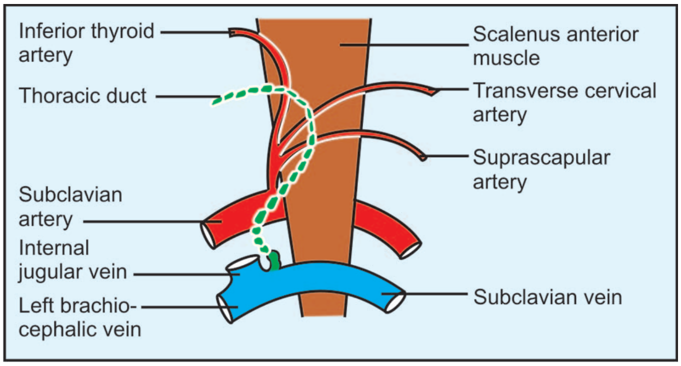



**Figure 202** Showing relations and termination of thoracic duct (left)

**Postero-inferior Relation:** Cervical pleura and the suprapleural membrane lie below and behind the artery. Right vagus as it crosses the first part of the right subclavian artery, gives the branch known as the right recurrent laryngeal nerve, which hooks it from below.

**First Part of the Left Subclavian Artery:** Arises from the arch of aorta and runs vertically upwards and laterally to the medial margin of the scalenus anterior muscle.

**Anterior Relation:** Same as that of the right side. Phrenic nerve, and the thoracic duct descend in front of the artery. Left brachiocephalic vein lies in front of it. Left recurrent laryngeal nerve after hooking the arch of the aorta lies medial the artery.

**Second Part:** Anterior relations of the second part are skin, superficial fascia, platysma, deep fascia, clavicular head of sternomastoid muscle, and scalenus anterior. Phrenic nerve on the right side lies in front of the scalenus anterior muscle and does not cross the artery directly as on the left side.

**Postero-inferior Relation:** Suprapleural membrane and the pleura.

**Brachiocephalic Vein:** It is formed by union of the internal jugular and the subclavian veins at the medial border of the scalenus anterior muscle. First part of the subclavian artery is accompanied by the brachiocephalic vein.

**Tributory:** External jugular vein, the only tributary joins it at the lateral border of the scalenus anterior, and is separated from the second part of the subclavian artery. It lies at the lower level than the artery.

*Branches of the subclavian artery:*

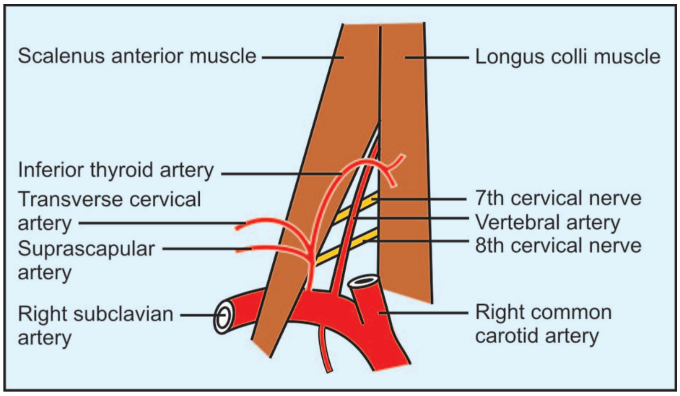
1. Branches of the first part
   i. Vertebral
   ii. Thyro-cervical trunk
   iii. Internal thoracic mammary artery.
2. Branch from the second part of the subclavian artery one, i.e. costocervical trunk which divides into two the deep cervical and superior intercostal arteries.

**Vertebral Artery (Figure 203):** It arises from the first part of the subclavian artery, ascends through the foramina in the transverse processes of the upper six cervical vertebrae.

Sometimes it may enter the foramen in the transverse process of the fifth cervical vertebra.

It comes out of the foramina transverserium of the atlas, runs postero-medialy around the lateral mass of the atlas and enters the foramen magnum. At the lower border of the pons it unites with the fellow of the opposite side to form the basilar artery.

**Figure 203** Showing 1st part of the vertebral artery




**Relations:** It is divided into four parts.

**First Part:** After its origin from the subclavian artery it runs upwards and backwards to enter the foramina transversarium of the transverse process of the sixth cervical vertebra. Medially it is related to the longus colli muscle and laterally to the scalenus anterior. Anterior to it lies the common carotid artery, vertebral vein and inferior thyroid artery. On the left side it is crossed by the thoracic duct. Posteriorly it is related to the transverse process of the 7th cervical vertebra and the anterior primary rami of 7th and 8th cervical spinal nerves, the sympathetic chain and the inferior cervical ganglion.

**Second Part:** Runs vertically upwards through the foramina transversaria of the upper 6 cervical vertebrae along with the sympathetic plexus and the vertebral venous plexus. Its course is almost vertical up to the transverse process of the axis. Thereafter it turns laterally and upwards to enter the foramen transverserium of the transverse process of the atlas.

**Third Part (Figure 205):** After leaving the foramen of the transverse process of the atlas it turns backwards and medially round the lateral mass of the atlas over the groove on the posterior arch of the atlas. Rectus capitis lateralies is lateral to it. Dorsal ramus of the first cervical nerve lies between the posterior arch of the atlas and vertebral artery. It passes under the posterior atlanto-occipital membrane and enters the foramen magnum. This part comes in the suboccipital triangle and is under cover of the muscle semispinalis capitis.

**Fourth Part:** It pierces the dura and the arachnoid and ascends in front of the rootlets of the hypoglossal nerve, turns medially and at the lower border of the pons unites with the fellow of opposite side to form the basilar artery.

*Branches:* Are mainly in two groups – the cervical and the cranial.

1. *Cervical:* Spinal branches, muscular branches (muscular branches anastomose with occipital artery) and the ascending and deep cervical arteries.
2. *Cranial:*
    1. *Meningeal:* May be one or two.
    2. *Posterior spinal:* It may arises from the vertebral but most commonly arises from the posterior inferior cerebellar artery.
3. *Anterior spinal artery*—Arises from the vertebral near its termination, unites with fellow of the opposite side to form a single trunk.

4. *Posterior inferior cerebellar artery :* This is the largest branch of the vertebral artery. Arises near the olive, runs behind the roots of the 9th and 10th cranial nerves to the lower border of the pons, where it turns downwards.
5. *Medullary arteries:* Numerous small branches which arise from the vertebral or from its branches.

**Vertebral Vein:** It passes downwards behind the internal jugular vein to open into the brachiocephalic vein.

**Thyro-cervical Trunk:** It arises from the first part of the subclavian artery, behind the internal jugular vein and in between the phrenic and vagus nerves. It divides into three branches, the inferior thyroid, transverse cervical and the supra-scapular.

**Inferior Thyroid Artery:** After its origin from thyrocervical trunk it runs upwards along the medial border of the scalenus anterior, under cover of the internal jugular vein. At the level of the cricoid it runs medially and crosses the vertebral artery. During this course it lies behind the vagus, sympathetic trunk and the common carotid artery. It reaches the middle of the posterior border of the thyroid gland. Now it turns down towards the lower end of the lobe of the gland. Here it gives tracheal, oesophageal and glandular branches.

*It gives following branches*
1. Ascending cervical,
2. Inferior laryngeal,
3. Tracheal
4. Oesophageal and
5. Glandular

(Inferior thyroid vein, instead of accompanying artery of its name, runs separately on the front of the trachea).

**Internal Thoracic Mammary Artery:** It takes origin from the first part of the subclavian artery near the medial border of the scalenus anterior. It runs downwards and medially to enter the thorax, behind the first costal cartilage. In the neck the artery is related to the pleura, behind, and the clavicle in the front. In front of the left artery lies the end of the subclavian vein and the beginning of the brachiocephalic vein. In front of the right lie the internal jugular and the brachiocephalic veins. The artery has no accompanying vein in the neck as the internal mammary vein drains into the brachiocephalic vein.

**Costocervical Trunk (Figure 206):** Arises from the second part of the subclavian artery under the medial margin of the scalenus anterior. It arches over the top of the cervical pleura and reaches the neck of the first rib. At the level of the neck of the first rib it divides into deep cervical and superior intercostal arteries. Deep cervical passes backwards between the transverse process of the seventh cervical vertebra and the neck of the first rib.

**Superior Intercostal Artery (Figure 208):** Superior intercostal artery which is one of the two terminal of the costo-cervical trunk runs in front of the neck of the first rib in between the first thoracic nerve and the first thoracic ganglion of the sympathetic chain. The nerve is lateral to the artery and the sympathetic chain is medial (NAC – from lateral to medial are the relations of front of the NECK of the first rib). It gives posterior intercostal artery of the first space and itself continues as posterior intercostal artery of the second space.

**Brachiocephalic Vein (Figures 204 and 207):** Brachiocephalic veins drain the blood from the head, neck and the upper limbs. They are partially in the neck and partially in the superior mediastinum. Each vein is formed behind the medial end of the clavicle and in front of cervical pleura by union of the internal jugular and the subclavian veins. They unite to form the superior vena cava opposite the lower border of the right first costal cartilage, behind the right margin of the manubrium sterni.

**Figure 204** Showing anterior relations of right and left internal thoracic mammary arteries

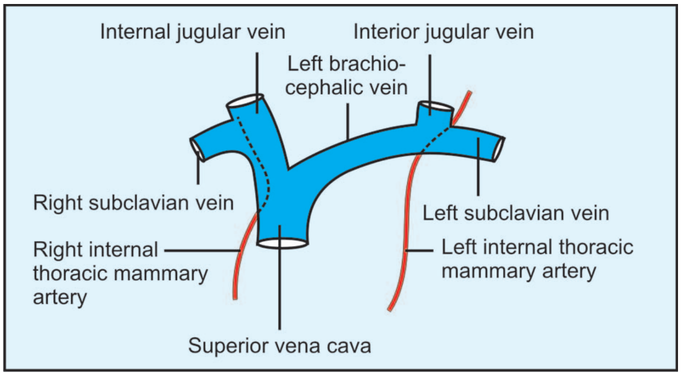



**Figure 205** Showing course of vertebral artery

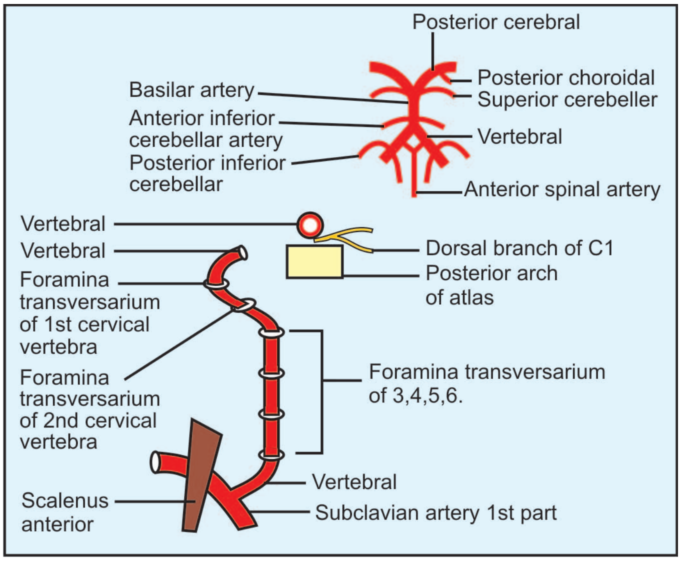



**Figure 206** Showing costocervical trunk

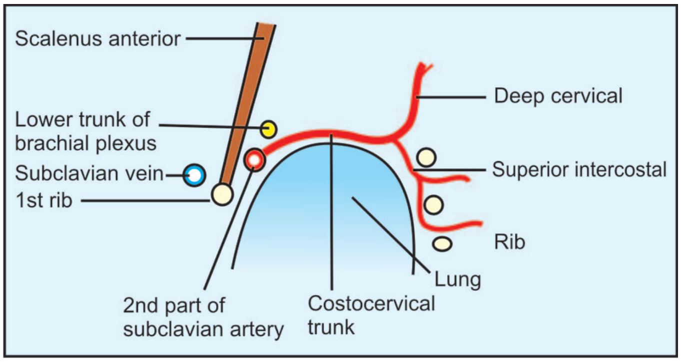
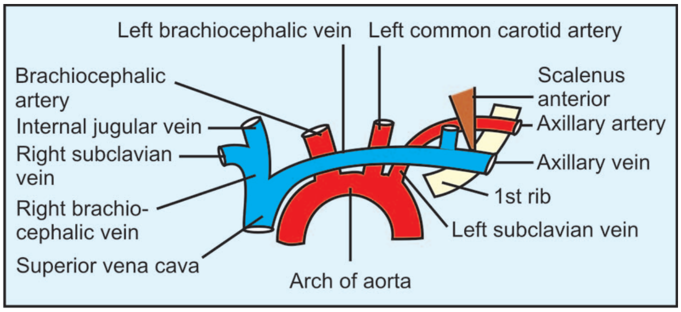



**Figure 207** Showing arch of aorta, its three branches, formation of brachiocephalic veins and superior vena cava




*Note:* Formation, joining and the end of the superior vena cava can be remembered as 1, 2, 3. It is formed at the level of 1, joined by the azygos vein at the level of second and ends into the right atrium at the level of 3 right costal cartilages.

**Right Brachio-Cephalic Vein:** Right brachiocephalic vein runs downwards and medially on the cervical pleura. It is separated from the pleura by the phrenic nerve and the internal thoracic mammary artery. It lies under the sternomastoid and the sternohyoid muscles, clavicle and costo-clavicular ligament. Vagus lies between the vein and the brachiocephalic artery on the posterior plane.

**Left Brachiocephalic Vein:** Left brachiocephalic vein crosses the mid-line under cover of the upper part of the manubrium, but in front of the three great branches of the arch of aorta, namely left subclavian, left common carotid and the brachiocephalic arteries. It crosses the trachea, vagi, phrenic nerves and internal thoracic mammary artery from the front.

**Tributaries in the Neck:** Left brachiocephalic vien receives the following veins:

1. Vertebral vein,
2. First posterior intercostal vein,
3. Thoracic duct,
4. Few lymph trunk and
5. Inferior thyroid veins or vein.

# THORACIC DUCT

Thoracic duct is the greatest lymphatic channel of the body. It drains the whole of the body below the diaphragm and upper half of the left of the body above diaphragm. Excepting the part of the right lobe of the liver and upper right quadrant of the anterior abdominal wall. It ascends in the thorax along the left border of the oesophagus, enters the root of the neck, reaches the level of the transverse process of the seventh cervical vertebra and turns to the left passing between the vertebral system behind and the carotid system infront. Vertebral system contains vertebral artery, vertebral vein and the sympathetic chain. While the carotid system consists of common carotid artery, internal jugular vein and the vagus nerve anteriorly. It runs across the apex of the pleura, lies on the left scalenus anterior muscle, the left phrenic nerve and crosses the first part of the sub-clavian artery. It opens into the jugulo-subclavian junction of the left. It is provided with the valve proximal to its opening into the jugulo-subclavina junction. The valve prevents the entry of the venous blood into the thoracic duct. However, after death the valve becomes non-functional and allows the entry of venous blood into the terminal part of the thoracic duct.

In addition there are three lymph trunks on each side at the root of the neck. They are the jugular, subclavian and the broncho-mediastinal. The left jugular trunk opens into the thoracic duct, subclavian, in the subclavian vein and the bronchomediastinal into the brachiocephalic vein.

On the right all three may have separate entrances. Subclavian and jugular lymph trunk join to form a right lymphatic duct which joins the brachiocephalic vein. Bronchomediastinal trunk may join the duct.

**Cervical Pleura (Figures 208 to 210):** The cervical pleura reaches the level of the neck of the first rib posteriorly. Due to obliquity of the first rib, front of the cervical pleura is seen above the sternal end of the first rib. It is protected by the suprapleural membrane which is also known as the Sibson's fascia. Sibson's fascia attached to the tip of the transverse process of the seventh cervical vertebra above, and the inner margin of the first rib below.

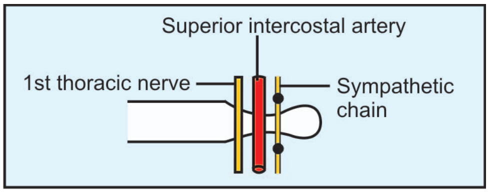



**Figure 208** Showing structures in front of the neck of 1st rib

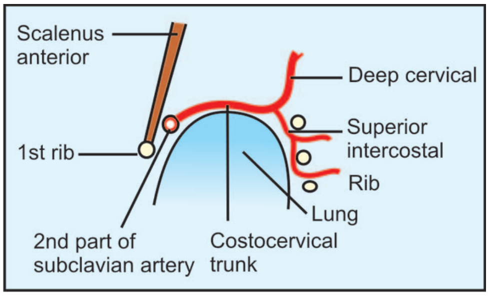



**Figure 209** Sagittal section through the apex of lung. Showing course of the costo-cervical trunk

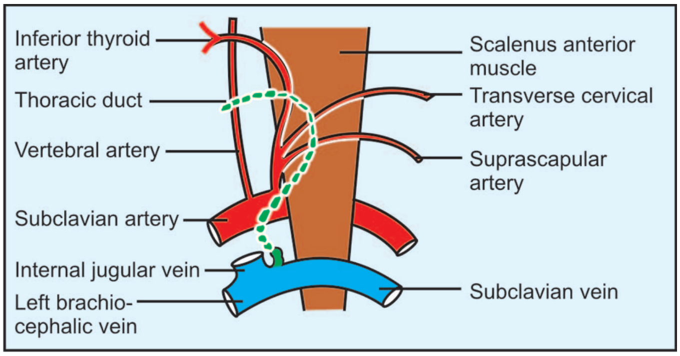



**Figure 210** Structures at the left side of the root of neck. Please note that the vertebral artery is crossed by the inferior thyroid artery and the thoracic duct from the front

Subclavian artery crosses the dome of pleura from the front a little below its apex. Vertebral artery is related to the antero-medial aspect. Internal mammary artery is seen running downwards and medially from the first part of subclavian. Costo-cervical trunk is related to the apex of the dome and its superior intercostal branch is related to posterior surface of the cervical dome. Naturally the structures which lie in front of the neck of the first rib (lateral to medial side are first thoracic nerve, superior intercostal artery and sympathetic chain or first thoracic ganglion) form the posterior aspect of the pleura. The subclavian artery, vagus, its recurrent laryngeal branch and ansa subclavian are related with the cervical pleura on the right. On the left the thoracic duct, is related to the dome of the cervical pleura, as it passes laterally and downwards for its end in the jugulo-subclavian junction. Please remember the relations of the duct during its course when it is directed laterally. It passes between the vertebral system and the carotid system; vertebral system being behind and the carotid being infront.

# COMMON CAROTID ARTERY

On each side it enters the neck behind the sternoclavicular joint, runs upwards backwards and laterally along and under cover of the anterior border of the sternomastoid muscle to the level of the upper border of the thyroid cartilage where it divides into two terminal branches, the internal carotid artery and the external carotid artery.

**Sheath:** Common carotid artery is enclosed in a common fascial sheath along with the internal jugular vein and the vagus nerve. Vein is lateral to the artery and tries to overlap it from the front when full. Vagus nerve lies in between the two at a more posterior plane.

## Relations (Figures 211 and 212)

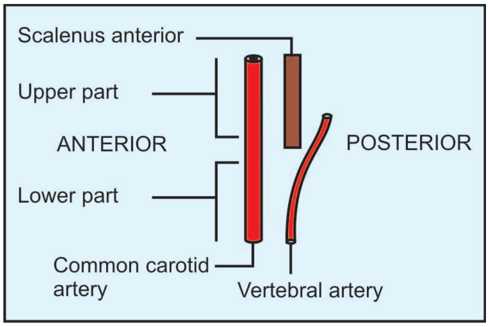



**Figure 211** Showing course of common carotid artery and its relation with scalenus anterior muscle and the vertebral artery (schematic)

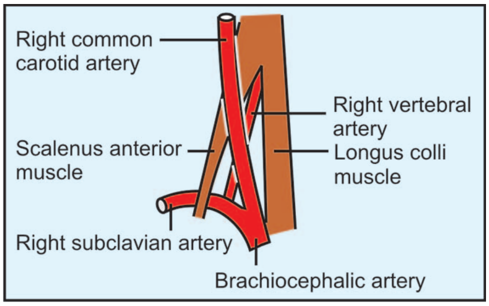



**Figure 212** Showing common carotid artery in front of the vertebral artery and the scalenus anterior muscle

**Posterior relations:** Anterior tubercles of the transverse processes of the lower four cervical vertebrae, scalenus anterior and longus capitis muscles are posterior to the common carotid artery. Anterior tubercle of the sixth cervical vertebra is known as carotid tubercle because the artery can be compressed against it. Prevertebral fascia, and sympathetic chain lie behind the artery in the upper part, and the vertebral and the inferior thyroid arteries in the lower part.

**Anterior relations:** Anterior border of sternomastoid, superior belly of omohyoid, sternohyoid and sternothyroid muscles, all lie superficial to the artery. Ansa hypoglossi and ramus descendens hypoglossi lie embedded in the anterior wall of the carotid sheath.

**Medial relations:** Thyroid gland, inferior constrictor, trachea, oesophagus, recurrent laryngeal nerve, larynx and pharynx are the medial relations.

**Laterally:** Internal jugular vein forms the lateral relation.

**Branches:** Normally no branch is given by common carotid artery except the two terminal.

**Carotid Sinus:** It is a localised dilation at the point of bifurcation of the common carotid artery or the beginning of the external carotid artery. Outer covering of this dilation is thick and it receives rich nerve supply from the 9th and sympathetic nerves. By virtue of structural specialization sinus wall acts as a part of reflex mechanism for regulating the blood pressure in the cerebral arteries.

**Carotid Body:** It is an oval body situated on the posterior aspect of the bifurcation of the common carotid artery. It gets its nerve supply from the 9th cranial nerve (Sino-carotid nerve). It consists of clumps of polyhydral cells and sinusoids. It is developed from the mesoderm of the third arch. It is sensitive to anoxia and pH of blood.

# INTERNAL JUGULAR VEIN

Internal jugular vein begins as the continuation of the sigmoid sinus, at the jugular foramen. It runs downwards and forwards, to the point behind the sternal end of the clavicle where it unites with subclavian vein to form the brachiocephalic vein, near the medial border of the scalenus anterior muscle (Figures 213 and 213A).

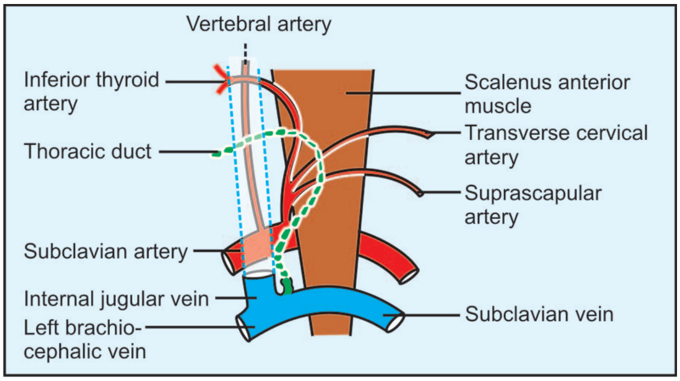



**Figure 213** Showing relation of the internal jugular vein on the left side of the root of neck

**Bulbs (Figures 214 to 216):** Internal jugular vein has two bulbs the superior and the inferior. The superior bulb is lodged in the jugular fossa of the temporal bone and forms the relation of the floor of the middle ear cavity. Inferior bulb of the internal jugular vein lies behind the clavicular and the sternal head of sternomastoid muscle. This area is marked by depression which is also known as lesser supraclavicular fossa. Proximal to the dilatation the inferior bulb is provided with a bicuspid valve (Figure 214A).

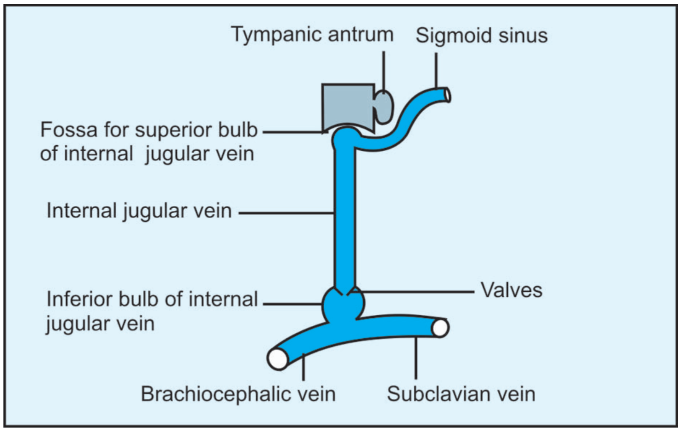



**Figure 213A** Showing formation course and termination of internal jugular vein

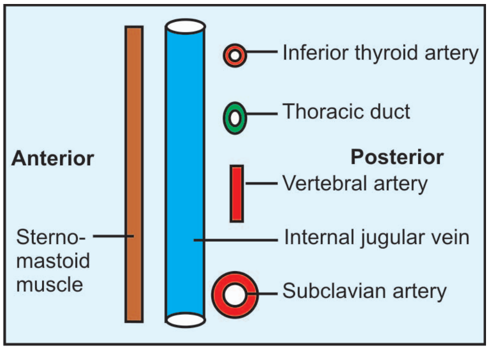



**Figure 214** Showing some anterior and posterior relations of the internal jugular vein in the lower part of the neck (schematic)

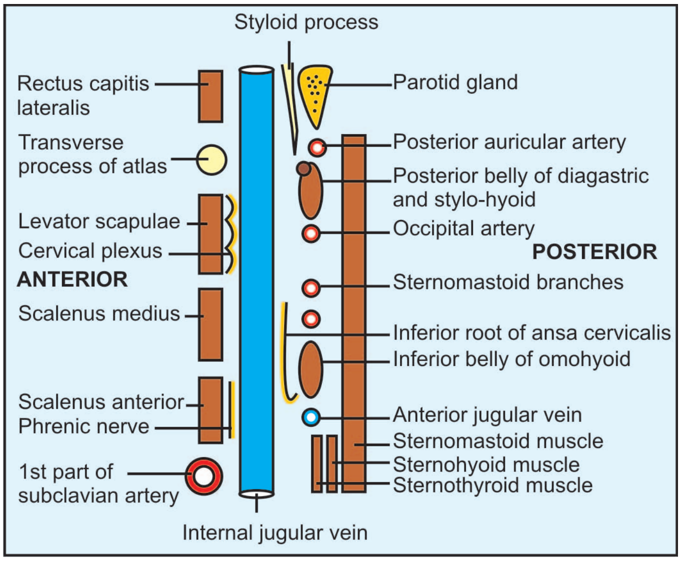



**Figure 214A** Showing anterior and posterior relations of the internal jugular vein (highly schematic)

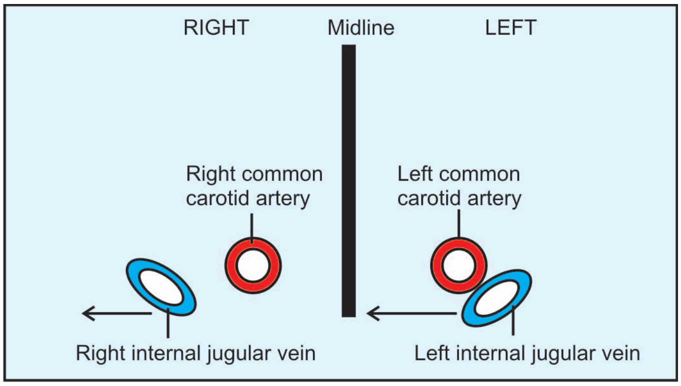



**Figure 215** Both the internal jugular veins have natural tendency to go to the right; hence, left IJV overlaps the left CCA and the right IJV goes to the right away from the right CCA (swinging of the internal jugular veins to the right)

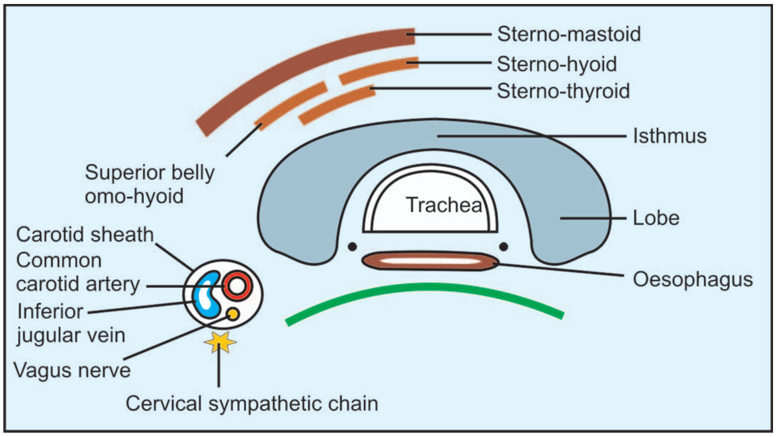



**Figure 216** Showing horizontal section of thyroid gland at the level of isthmus

The common carotid artery is related to the scalenus anterior muscle in the upper part and the vertebral artery in the lower. Vertebral artery lies in the triangular interval between the longus coli medially and the scalenus anterior muscle laterally (Figures 211 and 212).

## Relations of the Internal Jugular Vein

**Posterior Relations of the Internal Jugular Vein (see Figures 214A and 215):**

They are as under:

1. Rectus capitis lateralis
2. Transverse process of Atlas
3. Levator scapulae
4. Scalanus medius
5. Cervical plexus
6. Scalanus anterior
7. Phrenic nerve
8. Thyrocervical trunk
9. Vertebral vein
10. First part of the subclavian artery
11. Thoracic duct on the left.

**Superficial Relations of the Internal Jugular Vein (see Figures 214A and 215):**

The relations being multiple. They are divided into four.

i. At the base of skull
ii. Above the posterior belly of digastric
iii. Between the digastric and the superior belly of omohyoid.
iv. Below the superior belly of omohyoid.

i. At the base of skull:
   a. Internal carotid artery : is anterior
   b. 9th, 10th , 11th 12th cranial nerves are anterior to the jugular vein.

ii. Relations above the posterior belly of digastric and stylohyoid:

*They are as under:*

a. Parotid gland
b. Styloid process
c. Muscles attached to the styloid process
d. Accessory nerve
e. Posterior auricular artery
f. Occipital artery
g. Jugulo-digastric nodes

iii. Between the posterior belly of digastric and superior belly of omohyoid.
   a. Sternomastoid artery,
   b. Inferior root of ansa cervicalis,
   c. Jugulo-omohyoid group of lymphnodes.

iv. Below the superior belly of omohyoid.
   a. Sternomastoid muscle
   b. Sternohyoid muscle
   c. Sternothyroid muscles

In short one can remember as sternomastoid and infrahyoid muscles.

v. Anterior jugular vein:

**Medial Relations:**

Internal carotid artery and the vagus nerve between the internal jugular vein and the internal carotid artery at the posterior plane in the upper part of the neck. However in the lower part medially, it is related to the common carotid artery, thyroid gland, trachea and the oesophagus.

**Tributaries (Figure 217):**

Inferior petrosal sinus connect the cavernous sinus with the internal jugular vein.

1. Common facial vein.
2. Pharyngeal veins.
3. Lingual vein.
4. Superior thyroid vein.
5. Middle thyroid vein.

6. Occipital at times.
7. It may communicates with the external jugular vein through the oblique vein which lies superficial to the sternomastoid muscle.

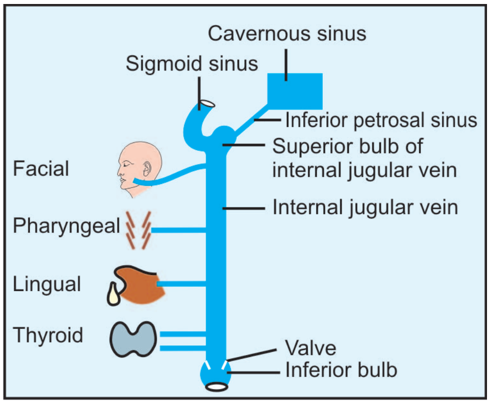



**Figure 217** Showing tributaris of internal jugular vein

**Clinical:**

1. Internal jugular vein is commonly used for recording central venous pressure. There are two approaches one in the neck and one through the infraclavicular fossa. In the neck mark the midpoint of the line joining the mastoid process and the sternoclavicular joint. Lateral to the pulsations of the common carotid artery or lateral to the superior border of thyroid cartilage.
2. From the infraclavicular fossa: the needle is passed below the clavicle at the meeting of medial and middle thirds of the clavicle. It is pushed upwords and medially in the direction of the upper manubrium sterni.
3. For recording the pressure of the right atrium as the right internal jugular vein is more in line with the right atrium.
   i. The selection of the right internal jugular vein is preferred for following two reasons:
      a. Right Internal Jugular vein is lateral to the right common carotid artery and does not overlap like the left jugular vein.
      b. It is in line with the right atrium as the right brachiocephalic, superior vena cava and right atrium are alined.
      c. Internal Jugular vein is cannalised (Central vein) for giving intravenous feeding for a long time.
      d. Internal Jugular vein is enlarged and gets dilated in congestive cardiac failure (CCF).
      e. In block dissection of the lymphnodes of the posterior triangles for malignancy, the internal jugular vein has to be sacrificed as the nodes are invariably adherent to the vein.

# EXTERNAL CAROTID ARTERY

The external carotid artery is one of the two terminal branches of the common carotid artery given at the level of the upper border of the thyroid cartilage (Level of the disc between 3 and 4 cervical vertebrae). It runs upwards with a slight convexity directed anteriorly, enters the substance of the parotid gland and divides into maxillary and superficial temporal arteries at the level of the neck of the mandible in the substance of the parotid gland. It is smaller in children, than the internal carotid artery, but equals in adults.

**Relations (Figure 218):**

Relations are studied under the following heads : It must be rememberd that the posterior belly of digastric and the stylohyoid muscles cross the artery superficially.

1. Above the posterior belly of digastric and stylohyoid: It lies deep to the parotid gland and enters the substance of the gland through the postero-medial surface and divides into the superficial temporal and the maxillary arteries at the level of the neck of the mandible.
2. Below the posterior belly of digastric: Anterior border of the sternomastoid, common facial vein and the 12th nerve form superficial relations.
3. Medial relation: Inferior and middle constrictor muscles and the internal and external laryngeal nerves.
4. Postero-lateral relation: It is related to the internal carotid artery.

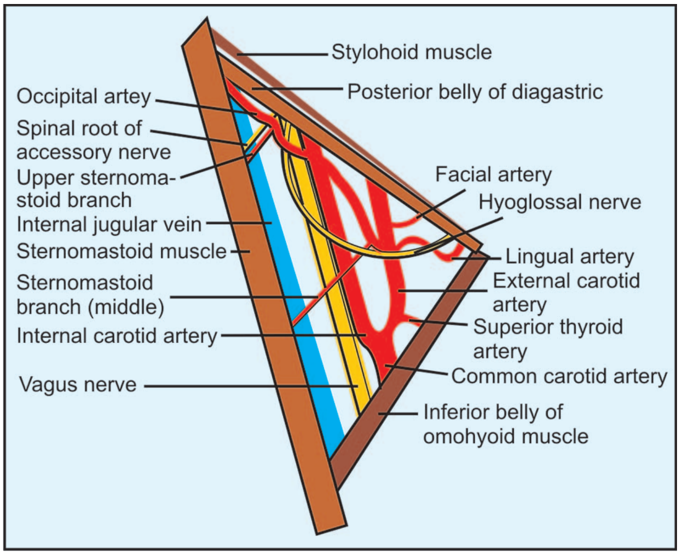



**Figure 218** Showing carotid triangle and contents. Please note that hyoglossal nerve crosses three arteries in the triangle

**Branches:**

It gives eight branches.

1. *Superior thyroid:* Superior thyroid arises from the anterior aspect of the external carotid artery. It gives infra hyoid, the sternomastoid, superior laryngeal and the cricothyroid arteries.
2. *Lingual artery:* Lingual artery is given at the level of the greater cornu of the hyoid where it forms the loop around the greater cornu of the hyoid. It is crossed by the hyoglossal nerve and the facial vein. It disappears under hyoglossus muscle where it gives dorsalis linguae arteries. As it comes out of the anterior border of the hyoglossus muscle it goes towards the tip of the tongue. After running along the anterior border of the hyoglossus muscle.

3. *Facial artery:* Facial arises from the anterior aspect of the external carotid artery in the carotid triangle just above the lingual and the greater cornu of the hyoid bone. It goes to the medial side of the ramus of the mandible, forms an upward curve and reaches the posterior aspect of the submandibular salivary gland. Next it runs between the gland and the medial pterygoid muscle. As it reaches the lower border of the mandible, it forms a curve at the antero-infero angle of the masseter muscle. Next it runs on the mandible, the buccinator and reaches the point lateral to the angle of mouth. It runs by the side of the nose and ends at the medial angle of the eye. It supplies lacrimal sac and joins the dorsal nasal branch of the ophthalmic artery. The artery has a coiled appearance which facilitates the movements of the pharynx during deglutition and the movements of the jaw by virtue of its extra length. At the end the artery is called as the angular artery. It is palpable at the antero-infero angle of the masseter muscle. During general anesthesia anesthetics keeps his finger on the facial artery. The artery can be compressed between the thumb and the index at the angle of mouth in the event of injury to the lips, to stop bleeding. In the neck it lies lateral to the superior constrictor and the styloglossus muscles where it gives the tonsillar branch and the ascending palatine artery. In the face it is under the skin, fat and the superficial modular muscle near the angle of mouth. It runs on the buccinator and the levator anguli-oris. At the end it is embedded in the levator labi superioris alaeque nasi. Facial vein lies posterior to the artery. Branches of the facial nerve cross the artery superficially. Branches of the facial artery in the neck are.
   a. Ascending palatine
   b. Tonsillar
   c. *Glandular:* For submandibular salivary gland and lymph nodes.
   d. *Submental artery:* It is the largest branch which arises from the facial artery. As it leaves the submandibular gland and runs below the lower border of the mandible on the mylohoid muscle. It divides into superficial and deep branches to supply the chin and the lower lip.

   *Branches of facial artery in the face:*
   a. *Inferier labial artery:* arises near the buccal angle passes into upper lip between the muscle and the mucous membrane. It anastomoses with the mental branch of the inferior alveolar artery and also with fellow of opposite side.
   b. Superior labial artery
   c. Lateral nasal supplies alae of the nose, dorsum of the nose and anastomoses with the dorsal nasal branch of the ophthalmic artery and the infra-orbital branch of the maxillary artery. It has an anastomosis with the septal and allar branches of the superior labial artery and the artery of the opposite side.
4. *Occipital artery :* Occipital artery arises from the back of the external carotid artery at the level of the facial artery and follows the lower border of the posterior belly of diagastric crossing the internal carotid artery, internal jugular vein and the 12th , 10th and the 11th nerves superficially. It reaches the occipital groove on the temporal bone deep to the mastoid process and the muscles attached to it, i.e. sternomastoid, splenius capitis and the longus cervisis, semi-spinalis capitis. It passes superficial to the muscles, rectus capitis lateralis, obliquus superior and semi-spinalis capitis. It pierces the deep fascia between the sternomastoid and the trapezius.

5. *Ascending pharyngeal artery:* It is the first branch of the external carotid artery.
6. *Posterior auricular artery:* It runs along the superior border of the posterior belly of diagastric muscle.

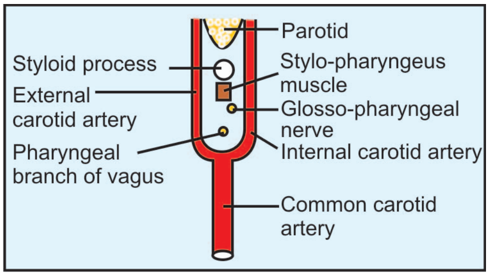
External carotid artery and its branches are accompanied by sympathetic filaments coming from the superior cervical ganglion is known an external carotid plexus.

**Ascending Pharyngeal Artery:** Ascending pharyngeal artery is the smallest, slender branch of the external carotid artery which has a long course. It anastomoses with the ascending palatine branch of the facial artery. It is the first branch of the external carotid artery given in the carotid triangle. It runs upwards by the side of the pharyngeal wall. It gives pharyngeal branch, which is distributed to the pharynx auditory tube, tonsil and the palate. In addition to this it gives muscular, inferior tympanic and the meningeal branches. The inferior tympanic branch passes through a canaliculus along with the tympanic branch of the 9th nerve.

**Internal Carotid Artery (Figure 219):** Internal carotid artery is one of the two terminal branches of the common carotid artery given at level of the upper border of thyroid cartilage. It runs from the upper border of the thyroid cartilage to the base of the skull where it passes into the carotid canal. Cervical portion of the artery is related to the longus capitis muscle, sympathetic chain, vagus, glossopharyngeal and the hypoglossal nerves postero-laterally. Internal jugular vein is posterior to it. Medially internal carotid artery is related to the constrictors of the pharynx. In the carotid triangle it is under the skin, superficial fascia, platysma and the anterior border of the sternomastoid muscle. It is crossed by the lingual, common facial veins, occipital artery and the hypoglossal nerve. It is crossed by the posterior belly of diagastric and stylohyoid muscles. Stylopharyngeus muscle and the styloid process lie between the parotid and the internal carotid artery.

Structures between external carotid and internal carotid arteries are : (1) styloid process, (2) stylopharyngeus muscle, (3) glossopharyngeal nerve, (4) pharyngeal branch of vagus and small part of the parotid gland.

**Figure 219** Showing structures between the internal and external carotid arteries



# CRANIAL NERVE

**Glossopharyngeal Nerve (Figure 220):** Glossopharyngeal nerve is a mixed nerve. Motor element is distributed to only one muscle, the stylopharyngeus and sensory supply is to the mucous membrane of the middle ear, the pharynx, posterior third of the tongue, the carotid body and the sinus. Secretary fibres for the parotid gland are distributed through the tympanic branch of the glossopharyngeal nerve which forms the tympanic plexus and leaves it as the lesser superficial petrosal nerve. Lesser superficial nerve gets relayed in the otic ganglion which lies under the trunk of the mandibular nerve in the infra-temporal fossa. From the otic ganglion fibres join the auriculo-temporal nerve to reach the parotid carrying the secretory fibres (Figure 220).

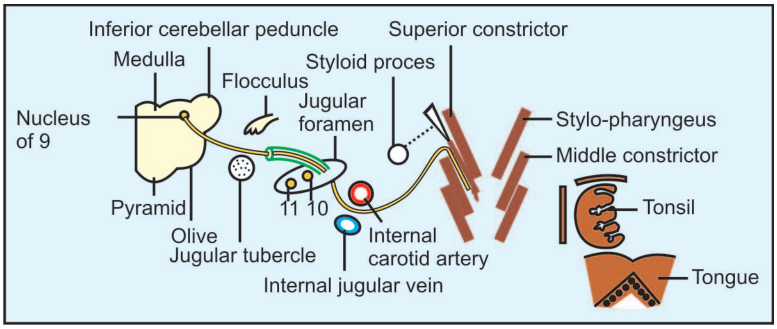



**Figure 220** Showing course and relation of glosso-pharyngeal nerve

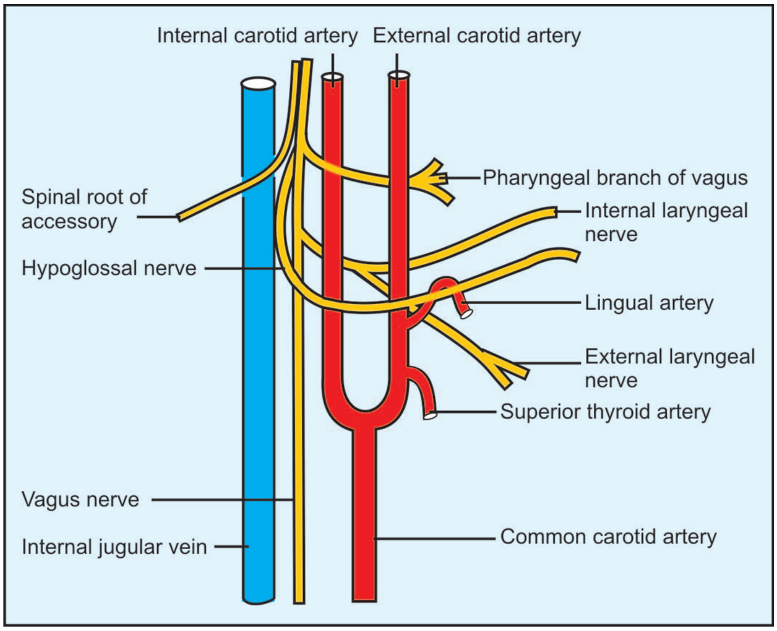
Two sensory ganglia are situated on the nerve in the jugular foramen.

**Course and Relations (Figure 220):** Glossopharyngeal nerve is attached to the side of the medulla above the rootlets of the vagus nerve and runs laterally and forward on the jugular tubercle under the flocculus. It reaches the triangular depression where acquae duct of the cochlea opens. Through the jugular foramen it runs vertically down in a separate sheath of dura. At the triangular depression it is separated from the 10th and 11th nerves by the inferior petrosal sinus. As it leaves the skull it passes forwards between the internal jugular vein and the internal carotid artery. It crosses the internal carotid artery deep to the styloid process the muscles attached to it and reaches the posterior border of the stylopharyngeus muscle. Next it lies on the stylopharyngeus, either pierces the lower fibres of the superior constrictor muscle or passes through the gap between the superior and middle constrictor muscles. It supplies the mucous membrane of pharynx, posterior one third of the tongue including the vallate papillae (general and special sense of the taste), tonsils and the mucous glands of the mouth.

**Connections:** It is connected to the sympathetic trunk, vagus and the facial nerve.

**Ganglia (Figure 221):** It has two ganglia, superior and the inferior. Inferior ganglion is larger and is lodged in a notch at the lower border of the petrous portion of the temporal bone. It contains the unipolar cells whose peripheral processes are concerned with sense of taste and general sensibility from the mucous membrane of the posterior one-third of the tongue including the vallate papillae. These processes convey general sensibility from the mucous membrane of the pharynx, soft palate and the fauces.

**Figure 221** Showing relations of vagus and its branches




*9th Nerve gives following branches: (Figure 222)*

1. *Tympanic* – it arises from the inferior ganglion,
2. *Carotid branch* – is distributed to the carotid body and sinus,
3. *Pharyngeal branches* – 3-4 filaments which take part in the foramation of the pharyngeal plexus opposite the middle constrictor of the pharynx.
4. *Muscular branch* – to stylopharyngeus muscle,
5. *Tonsillar branches* – supply the tonsil and form plexus around the tonsil with the lesser palatine nerve which supplies the soft palate and fauces,
6. *Lingual branches* – They carry general and the special sensations from the posterior one-third of the tongue.

**Summary of 9th Nerve:**

I remember distribution of glosso-pharyngeal nerve by remembering the following sentence i.e.: glosso/-pharyngeal/ carotica/parotica/ tympani/ tonsilli. (Glosso-posterior one third of the tongue, Pharyngeal – Stylopharyngeus muscle, Carotia – Carotid body and the carotid sinus/ Parotica – Parotid gland/ Tympani . Tympanic cavity / Tonsilli – Tonsil.).

Vagus Nerve (Figure showing relations of the vagus and its branches.)

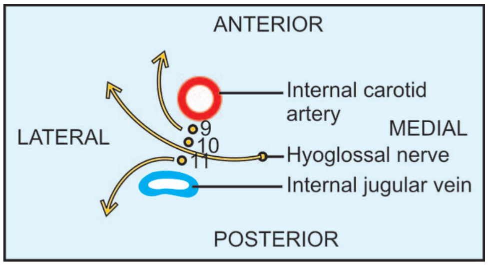
It is a mixed nerve and has very extensive distribution.

**Nuclei (Figures 221 to 223):**

Three nuclei in the medulla have connections with it.

1. Dorsal nucleus has both motor and the sensory component,
2. *Nucleus ambiguus:* It innervates the constrictors of pharynx and intrinsic muscles of the larynx. As regard's the muscles of soft palate it is uncertain whether they are innervated by the vagal portion of the nucleus ambiguous or by the cranial root of the accessory.
3. *Nucleus of the tractus solitarius:* Receives the fibres brought by the internal laryngeal nerve from the taste-buds of the epiglottis and the valecullae.

**Figure 222** Showing relations of the vagus at the base of the skull



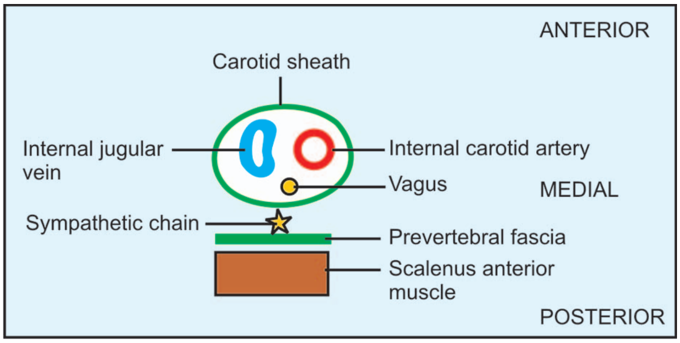



**Figure 223** Showing relations of the vagus while in the carotid sheath

**Ganglia:** It has superior and the inferior ganglia. Beyond the inferior ganglion, cranial root of the accessory joins with the vagus. Superior ganglion is concerned with general somatic sensations and the inferior with the special visceral and general visceral sensations.

**Course and Relations:** At the surface of the medulla it is attached by several rootlets, between the inferior cerebellar peduncle and the olive, below the roots of the 9th nerve. It runs laterally under the flocculus to the jugular foramen in the common sheath of dura along with the 11th nerve. It descends vertically down in the carotid sheath, along with the internal carotid, common carotid arteries and the internal jugular vein. Above the level of the upper border of the thyroid cartilage it lies between the internal jugular vein and the internal carotid artery and below the level of the upper border of thyroid cartilage it lies between the internal jugular vein and the common carotid artery. On the right side it crosses the front of the subclavian artery where it gives recurrent laryngeal nerve. On the left side vagus descends in front of the subclavian artery into the thorax between the left common carotid and the left subclavian arteries and crosses the arch of aorta. At the lower border of the aortic arch it gives the left recurrent laryngeal nerve.

**Branches:**

1. Meningeal
2. Auricular
3. Pharyngeal
4. Superior laryngeal,
5. Cardiac and
6. The right recurrent laryngeal nerve in the neck.

Cranial root of the accessory joins the vagus and is distributed through the pharyngeal, laryngeal and cardiac branches. Meningeal branch arises in the jugular foramen, and turns upwards to supply the dura of the posterior cranial fossa. Pharyngeal branch takes origin from the vagus immediately below the skull. It passes downwards and forwards between the internal carotid and the external carotid arteries. Superior laryngeal arises just below the origin of the pharyngeal branch. It passes deep to the internal carotid artery and divides into the internal and the external laryngeal nerves.

Internal laryngeal, accompanied by the superior laryngeal artery pierces the thyrohyoid membrane and supplies the mucous lining above the level of the vocal cords. External laryngeal nerve gives filaments to the inferior constrictor muscle and ends in the cricothyroid muscle, the only intrinsic muscle of the larynx situated outside and supplied by the external laryngeal nerve. (All the intrinsic muscles of the larynx are supplied by the recurrent laryngeal except the cricothyroid which is supplied by the external laryngeal nerve). Crico-thyroid is the only tensor of the vocal cords.

**Right Recurrent Laryngeal Nerve:** The right recurrent laryngeal nerve arises from the vagus as it crosses the subclavian artery. It hooks round the subclavian artery and passes deep to the common carotid artery to occupy the groove between the oesophagus and the trachea. On either side both recurrent laryngeal nerves pass upwards in the grooves between oesophagus and the trachea. They are related to the thyroid gland. It slips under cover of the inferior border of the inferior constrictor muscle of the pharynx, makes an entry into the larynx and communicates with the internal laryngeal nerve.

**Accessory Nerve:** Accessory nerve has the cranial and the spinal roots. It is purely motor. Lower end of the nucleus ambiguous gives origin to the cranial root. Spinal root arises from the elongated nucleus of the motor cells situated in the lateral part of the anterior grey column of the spinal cord, as low as the level of the 5th cervical segment (Figures 224 to 226).

**Figure 224** Showing origin of crenial and the spinal root of the accessory nerve

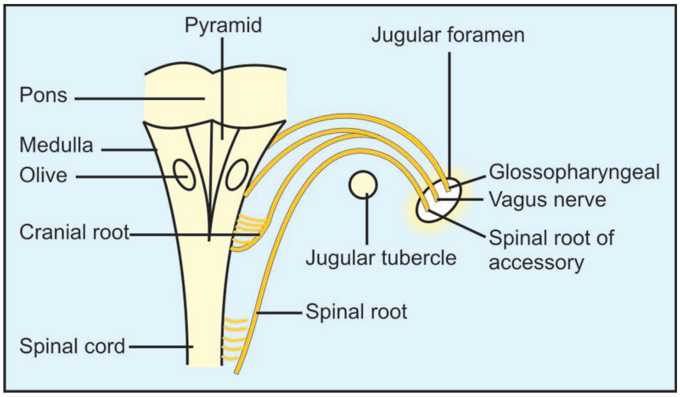



**Figure 225** Showing relations of the vagus nerve at the base of skull

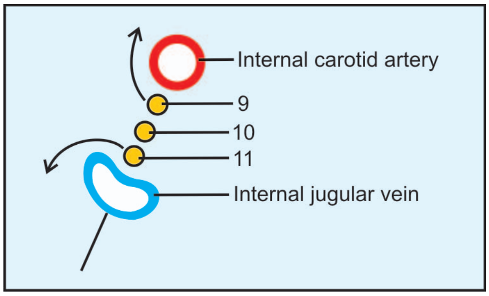
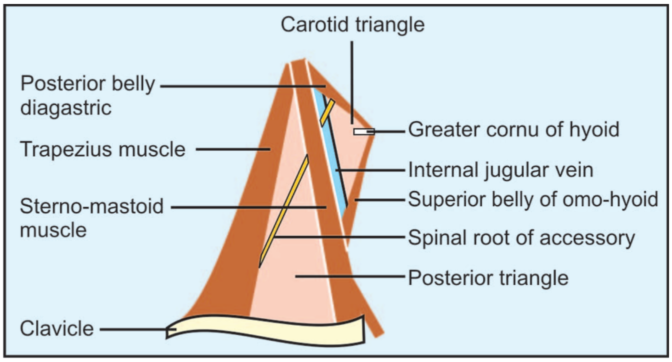



**Figure 226** Showing spinal root of accessory in carotid and posterior triangle (diagrammatic)




Fibres emerge from spinal cord between the ventral and the dorsal nerve roots. They unit to form the nerve trunk which enters the foramen magnum behind the vertebral artery. It runs upwards and laterally towards the jugular foramen. It is enclosed in the common dural sheath along with the vagus, separated from the vagus by the fold of arachnoid matter. In the jugular foramen it meets the cranial root which joins the vagal trunk and

is mainly distributed by the pharyngeal branches of the vagus. It runs downwards and backwards deep to the internal jugular vein in 66 percent of the cases and superficial to it in 33 percent of the cases. It crosses the transverse process of the atlas and is itself crossed by the occipital artery. During its further course it is deep to the styloid process, muscles attached to it and the posterior belly of diagastric muscle. In company with the upper sternomastoid branch of the occipital artery, it passes deep to sternomastoid and enters its substance. It appears approximately at the mid-point of the posterior border of the sternomastoid muscle and runs obliquely downwards in the root of the posterior triangle on the levator scapulae. It disappears under cover of the anterior border of the trapezius muscle 5 cm. above the clavicle. It forms the plexus on the deeper surface of the trapezius muscle along with the branches from the 3rd and 4th cervical nerves. In the roof of the posterior triangle it is company of the small superficial cervical lymph nodes.

**Clinical:** Clonic spasm due to central irritation is known as spasmodic torticollis.

# HYPOGLOSSAL NERVE

Hypoglossal nerve is purely a motor, for the muscles of the tongue, both the intrinsic and the extrinsic. In addition to above supplies the genio-hyoid and thyro-hyoid muscles, the branches being from the first cervical nerve.

**Nucleus:** The nucleus is about 2 cm. long and its upper end corresponds with the hypoglossal triangle in the floor of the 4th ventricle. Lower down the nucleus is situated in the ventral part of grey matter. Fibres run forwards through the medulla and emerge on the surface as the number of rootlets between the olive and the pyramid.

**Course (Figures 227 and 228):** Rootlets unit to form two bundles, which pierce the dura separately, opposite the anterior condylar canal. As soon as it comes out of the canal it unites to form the single trunk. It comes out of the anterior condylar canal and lies deep to the internal carotid artery, internal jugular vein, 9th, 10th and 11th cranial nerves at the base of the skull. The nerve passes laterally between the internal carotid artery and the internal jugular vein. It makes a half spiral around the posterior aspect of the inferior ganglion of the vagus. Here it is deep to styloid process and muscles attached to it. It descends vertically downwards and appears at the lower border of the posterior belly of the digastric muscle between the internal carotid artery and internal jugular vein. We have studied this part of the nerve in the carotid triangle. It loops round the lower sternomastoid branch of the occipital artery, which crosses the nerve superficially. The hyoglossal nerve is set for a big event of crossing the arteries successively three times. It crosses the internal, external carotid arteries and the loop of the lingual artery at the greater cornu of the hyoid. (It can be called as the hat-trick by the hyoglossal nerve (Dictionary meaning of the word "hat-trick" is three successes of the same kind in the game). On the hypoglossal muscle it is related the deep part of submandibular gland, submandibular duct and the submandibular salivary ganglion. During its further course it lies on the genioglossus muscle and runs in its substance up to the tip of the tongue.

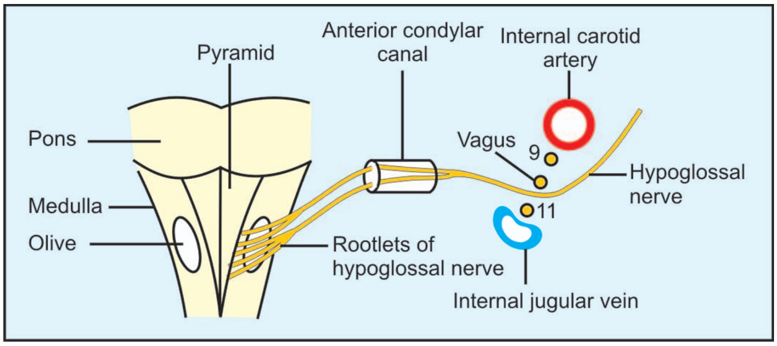



**Figure 227** Showing origin of the hypoglossal nerves from the front of medulla between the pyramid and olive

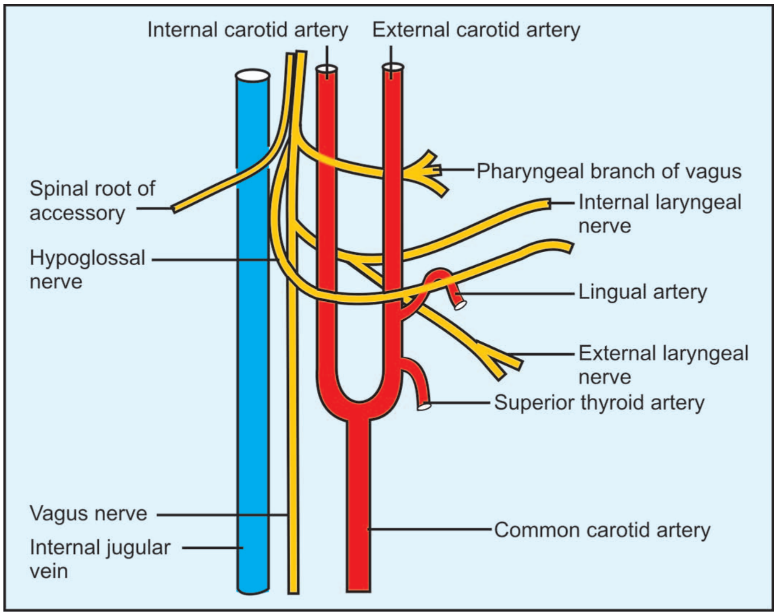



**Figure 228** Showing hypoglossal nerve in the carotid triangle. It crosses the internal carotid, external carotid and the loop of the lingual successively one after another (Hat-tric of hypoglossal nerve)

*Hypoglossal nerve communicates with the following:*

1. Sympathetic,
2. Vagus,
3. First cervical,
4. Second cervical and
5. Lingual.

Opposite the atlas it receives a filament from the loop between the first and the second cervical nerves. This component leaves the nerve soon in the form of a upper root of ansa cervicalis (descenders hyoglossi).

*Branches:*

1. Meningeal branch
2. Descending branch (descends cervicalis),
3. Nerve to thyrohyoid arises from it near the posterior border of the hypoglossus. It crosses the greater cornu of hyoid and supplies the thyrohyoid muscle,
4. Muscular—All the extrinsic and intrinsic muscles of the tongue are supplied by the hypoglossal nerve except the palatoglossus, which being the muscle of palate is supplied by the cranial root of the accessory.

**Clinical:** It acts as an important guide for ligation of the lingual artery. In case of the unilateral paralysis, hemiatrophy of the tongue occurs. Protruded tongue is directed to the paralysed side due to the unopposed action of the muscles of opposite side. In case of the bilateral paralysis (due to the wound of the suprahyoid region) tongue lies motionless, swallowing is difficult, however, the taste and tactile sensation are perfectly normal.

# SYMPATHETIC TRUNK

It lies vertically on the longus capitis and cervicis (longus colli) muscles, medial to the vagus and behind the carotid sheath. At its upper end it presents the superior cervical ganglion and continues in the skull as the internal carotid nerve. Lower down it crosses in front of the neck of the first rib. Vertebral artery lies in front of the lower part of sympathetic chain. Inferior thyroid artery may cross the chain from the front or the back. Each trunk consists of three ganglia i.e. the superior, middle and the inferior.

**Important:** This part gives grey rami communicants to all the cervical nerves but receives no white rami from it. They are brought from the thoracic region. There are 8 cervical nerves and 3 cervical sympathetic ganglion.
Upper 4 cervical nerves are connected with superior cervical ganglion.
5.6 Cervical are connected with middle cervical ganglion.
7.8 Cervical are connected with inferior cervical ganglion.

**Superior cervical ganglion:** Superior cervical ganglion is formed by the fusion of cervical four ganglion. It lies opposite the 2nd and 3rd cervical vertebrae on the longus capitis muscle posterior to the internal carotid artery. It is the largest ganglion of this trunk and has a length of about 2.5 cm.

**Branches:**

1. To the 9th, 10th and 12th nerves.
2. Grey rami communicating to upper 4 cervical nerves.
3. Internal carotid nerve.
4. Pharyngeal branch.
5. External carotid nerves-accompany the artery of the same name.
6. Cardiac branch-ends in the superficial cardiac plexus on the left side but on the right side it ends in the deep cardiac plexus.

**Middle cervical ganglion:** It lies at the level of the cricoid cartilage on the inferior thyroid artery and under the common carotid. It is smallest in size and gives following branches.

1. Grey rami to 5th and 6th,
2. Thyroid branch along with inferior thyroid artery,
3. Cardiac branch ends in deep cardiac plexus,
4. Ansa subclavia comes from middle cervical, runs in front of subclavian and loops around it and joins the inferior cervical ganglion. It communicates with the phrenic and gives filaments to the subclavian artery.

**Inferior cervical ganglion:**

- It is largest of the cervical sympathetic ganglia formed by the fusion of the 7th and the 8th.
- Sometimes the inferior cervical ganglion and first thoracic form cervico-thoracic or stellate ganglion.

**Stellate ganglion: (Figures 229 and 230)** Stellate ganglion lies between the base of the transverse process of 7th cervical vertebra and the neck of the first rib. It lies in front of the anterior primary ramus of 8th cervical nerve. It lies behind the vertebral artery and vein. It is separated from posterior part of cervical pleura by the suprapleural membrane. It lies on the lateral margin of longus cervicis muscle and medial to the superior intercostal artery.

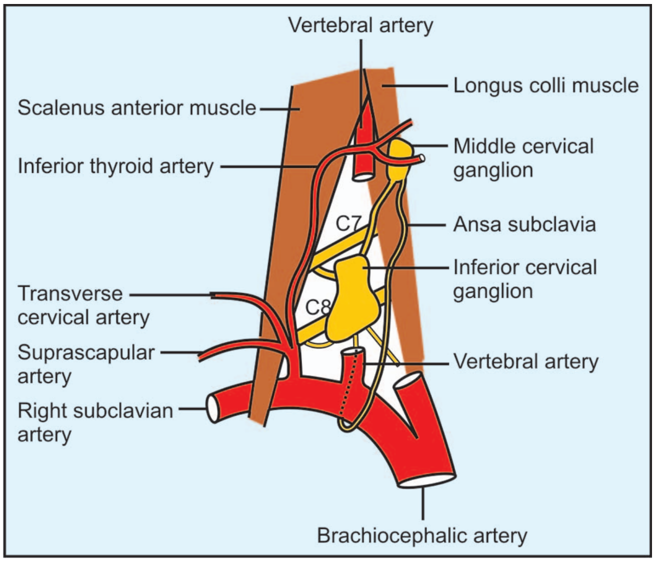



**Figure 229** Showing relations of inferior cervical ganglion as seen from the front

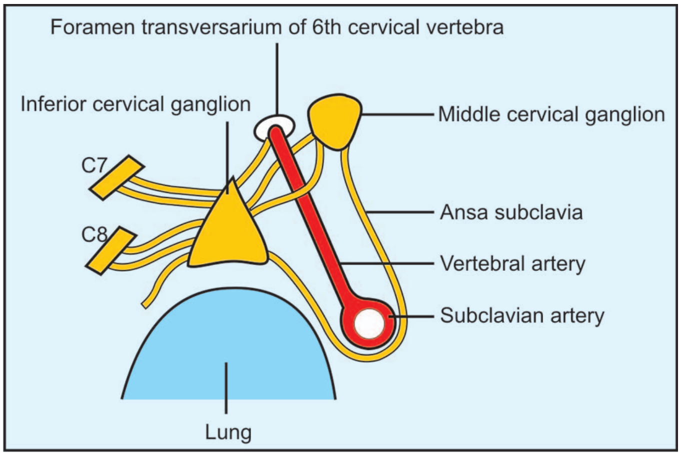



**Figure 230** Showing relations of the inferior cervical ganglion as seen from the side

**Branches:** Grey rami communicates with 7th – 1- 5 branches. 8th – 3 – 6 branches.

**Grey rami with the 7th:** One may ascend in front of the transverse process of the 7th cervical vertebra and communicates with 7th and then passes into foramen transversarium of the 6th cervical vertebra and joins the 6th also. Others may pass into foramen transversarium of the 7th vertebra.

*8th : Are multiple*

**Cardiac Branch:** Sometimes it may be replaced by fine branches from inferior cervical ganglion and ansa subclavia. It arises from inferior cervical ganglion or first thoracic ganglion, descens behind subclavian artery in front of trachea to reach the deep cardiac plexus.

It communicates with recurrent laryngeal and middle cardiac branch. Branches along arteries are

1. Verteral ,
2. Sub-clavian up to first part of axillary artery,
3. Inferior thyroid.

**Vertebral:** From inferior cervical ganglion alongwith vertebral artery, pass to foramen transversarium of 6th cervical ascends upwards, sends branches to anterior primary rami of upper 5-6 cervical nerves. It accompanies vertebral, basilar and posterior cerebral arteries.

It communicates with the plexus of inferior cervical ganglion.

**Inferior Thyroid:** This plexus communicates with,

1. External laryngeal nerve.
2. Recurrent laryngeal nerve,
3. Superior cardiac nerve,
4. Common carotid plexus.

Vasoconstrictor fibres to the arteries in the upper limb pass from ganglion to lower trunk of the branchial plexus and are distributed to the vessels, along the median nerve.

Preganglionic fibres for upper limb are from 2 to 6 thoracic. From 2 to 6 thoracic segments they go to the cells in inferior cervical ganglion and from here the post-ganglionic fibres go to lower trunk. Most of the vasoconstrictor fibres of the upper limb emerge from anterior roots of 2nd and 3rd thoracic nerves.

Thoracic-1 is not cut as it does not contain many vasomotor fibres to upper limb, but contains preganglionic fibres to be relayed in the superior cervical ganglion. From here postganglionic fibres supply the vasomotor (constrictor) sudomotor to face and the neck, dilator pupillae and to the involuntary muscle of upper lid. (Muller's muscle).

**Horner's Syndrome:** Destruction of this nerve leads to – (1) Constriction of pupil, (2) Ptosis, (3) Absence of sweating of face and neck of the same side.

**Blood Supply :** Blood supply is from –

1. Inferior thyroid artery,
2. Superior intercostal artery,
3. Mediastinal branch of thyrocervical trunk,
4. Sometimes from vertebral artery.

# PHRENIC NERVE

Phrenic nerve arises from the 4th cervical and gets insignificant contributions from the 3rd and the 5th. It is formed on the scalenus medius at the lateral border of the scalenus anterior, under cover of the sternomastoid at the upper border of the thyroid cartilage. It runs from lateral to medial side, gradually crossing the front of the scalenus anterior muscle. It is plastered to the muscle by means of the prevertebral fascia. On the scalenus anterior it is overlapped by the internal jugular vein and is crossed by the inferior belly of the omohyoid and the branches of the thyrocervical trunk. Left nerve is crossed by the thoracic duct and next it leaves the scalenus anterior to cross in front of the first part of the subclavian artery to open in the left jugular subclavian junction. Right nerve crosses the internal mammary thoracic artery usually in front of it but may pass behind it. Sometimes 5th cervical root may descend into the thorax and join the phrenic. At times this root may come from the nerve to the subclavius (Accessory phrenic nerve). (Figures 231 to 233).

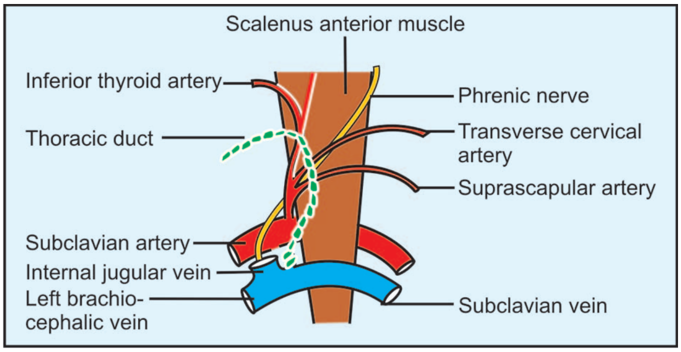



**Figure 231** Showing relations of the left phrenic nerve at the root of the neck

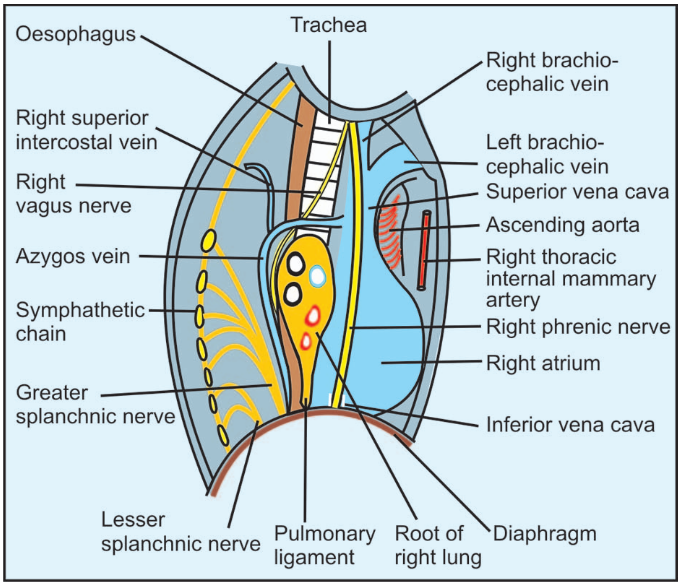



**Figure 232** Showing mediastinum seen from the right

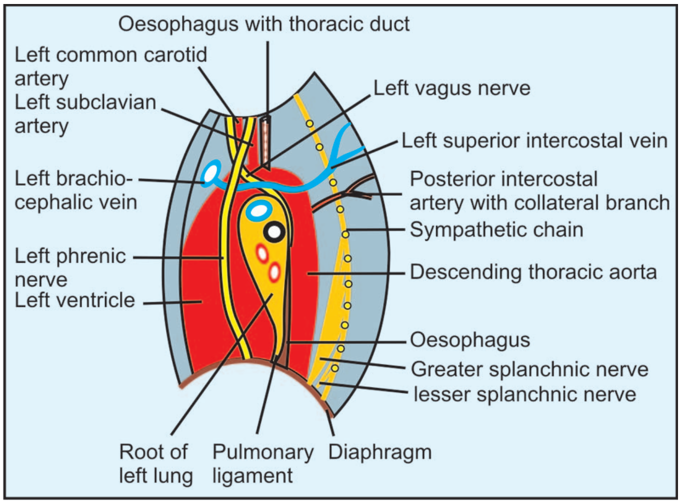



**Figure 233** Showing mediastinum seen from the left

Following are the differences between the right and the left phrenic nerves.

| *Right* | *Left* |
|---|---|
| 1. More deeply placed. | Less deeply placed. |
| 2. Shorter and vertical. | Longer |
| 3. Descends lower down on the scalenus anterior. | Leave the scalenus anterior earlier. |
| 4. Does not cross the first part of sub-clavian artery. | Crosses the first part of subclavian artery. |
| 5. No crossing by thoracic duct. | Crossed by the thoracic duct. |
| 6. Lies lateral to the right brachio-cephalic vein. | Lies behind in left brachiocephalic vein. |
| 7. Lies lateral to the superior vena cava. | Lies between the right subclavian and the right common carotid arteries. |
| 8. No crossing of vagus. | Crosses superficial to vagus. |
| 9. Lateral to the right atrium and the inferior vena cava. | Crosses the aortic arch and the left superior intercostals vein and runs down on the left ventricle. |

**Scalenus Medius:** Arises from the posterior tubercles of all the cervical vertebrae and gets inserted into the oval impression on the first rib. Posteriorly at its insertion it is related to the tubercle of the first rib and anteriorly to the groove for the subclavian artery.

**Relations:**

A. Anterior :
   1. Branchial plexus:
   2. Third part of subclavian artery.
   3. Anterior border its lower part is related to the apex to the pleura.

B. *Posterior:* Border is related to the levator scapulae. Nerve to rhombodis and deep branch of the transverse cervical artery pass between posterior border of the scalenus medius and the levator scapulae muscles.

**Scalenus Posterior:** Small muscle, arises from the lower 2 to 3 transverse processes of the cervical vertebrae and gets inserted into the upper border of the second rib posterior to the origin of serratus anterior muscle.

# PREVERTEBRAL REGION

**Muscles:** Mainly three pairs are seen. They are rectus capitis anterior, longus cervicis and the longus capitis.

**Longus Cervicis:** It is medially situated and runs from the anterior tubercle of the atlas to the third thoracic vertebra.

**Rectus Capitis Anterior:** It arises from the anterior aspect of the lateral mass of the atlas and runs upwards and medially to get inserted in front of the occipital condyle.

**Longus Capitis:** It is situated between the longus cervicis and the rectus capitis anterior overlapping both of them to some extent. It arises form the 3rd, 4th, 5th and the 6th cervical transverse processes and gets inserted into the base of the skull, into the area in front of the insertion of the rectus capitis anterior. It is worth mentioning that the origin of the sclaneus anterior and the origin of the longus capitis are the same, e.g. 3, 4, 5, 6 cervical vertebrae. (All the typical cervical vertebrae).

**Intertransverse Muscles (Figures 234 and 235):** Small slips are present in between the two transverse processes. Intertransverse muscles lie in between the two adjoining transverse processes. Rectus capitis anterior and the rectus lateralis represent the similar muscles. Ventral ramus of the cervical nerve passes in between two muscles and the dosal ramus runs across the medial border of the posterior as it courses backwards.

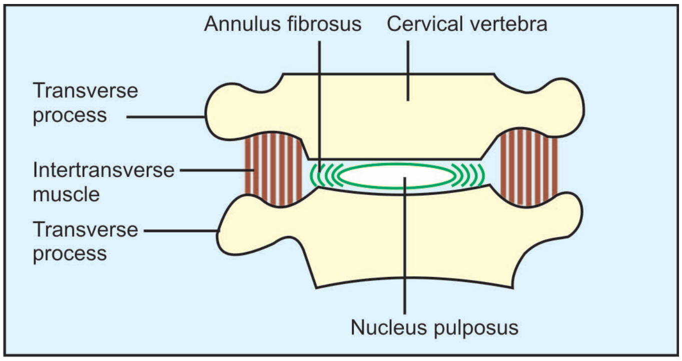



**Figure 234** Showing intertransverse muscles

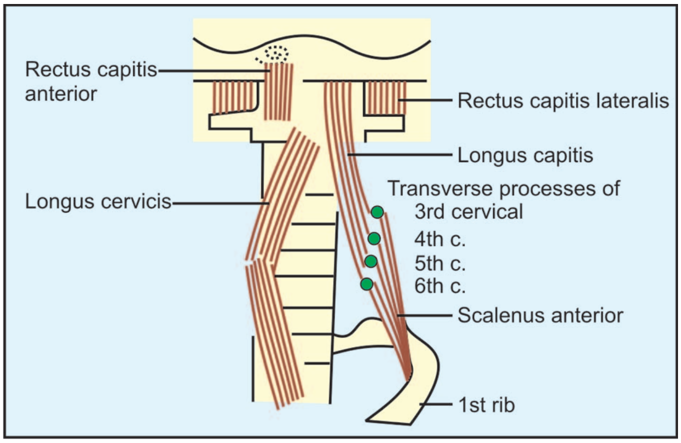



**Figure 235** Showing prevertebral region

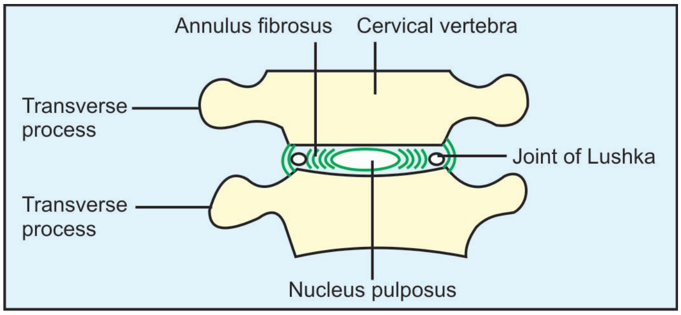
# JOINTS OF NECK

**Typical Cervical Joint (Figure 236):** It is similar to any other joint between the two vertebrae, but the following additional characters are to be kept in mind.

1. Between the two cervical vertebrae there are 3 joints. Central joint is in between the bodies where an intervertebral disc connects two adjoining bodies. It is a secondary cartilaginous type of joint.
2. Two small synovial joints (Joints of Lushka lie between the lateral most parts of the adjoining bodies. Osteo-arthritis of their joints leads to bony osteophytes which may press on cervical nerve (cervical spondylitis).
3. Intervertebral disc is thicker anteriorly.

**Joints between Axis and Atlas:** There are three synovial joints between these two. One on each side lies between the lateral masses of atlas and the body of the axis and the 3rd one lies between the dens and the anterior arch of the atlas.

**Figure 236** Showing joint between cervical vertebrae




**Anterior Atlanto-occipital Membrane:** Connects the upper border of the anterior arch of the atlas with the anterior border of the foramen magnum.

**Posterior Atlanto-occipital Membrane (Figure 237):** Attached to the posterior arch of the atlas below and the posterior border of the foramen magnum above. On either side it reaches the atlanto-occipital joint capsule. Under its free margin vertebral artery disappears.

**Membrana Tectories (Figure 237):** Below it is attached to the back of the body of the axis, and is continuous with the posterior longitudinal ligament. It runs upwards forming a cover for the odontoid process and gets attached to the upper surface of the occipital bone, after passing through the foramen magnum.

**Accessory Atlanto-axial Ligament:** It is placed one on either side. It is attached to the back of the body of the axis near the base of the odontoid process and runs upwards and laterally to gets attached to the lateral mass of the atlas. They assist the alar ligaments in limiting the rotation between the atlas and axis.

Figure 237 Showing superior suface of atlas

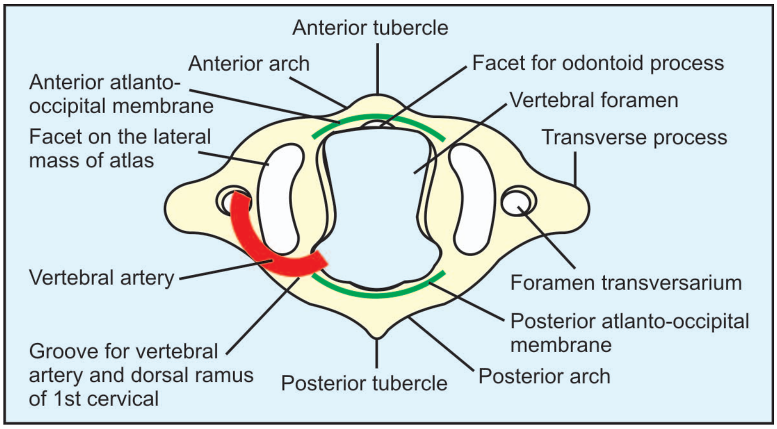
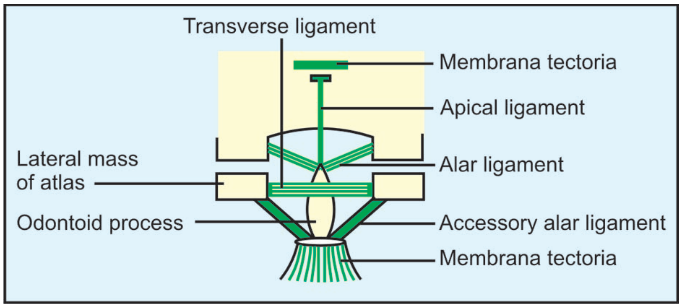



Figure 238 Showing apical, alar, transverse and accessory ligament. The membrana tectoria is cut to show the underline structures




**Transverse Ligament:** Runs from medial side of one lateral mass to the other for its attachment into the corresponding area. It separates the odontoid process from the medulla. In front of the odontoid process where exists a synovial joint. Similarly there is a synovial joint at the back of it, which lies between the odonoid process and the transverse ligament.

**Apical Ligament:** Runs from the tip of the odontoid process to the anterior margin of foramen magnum inside the cranium.

**Alar Ligament:** They are present in pair, and are very strong in structure. It is attached to the top of the odontoid process inferiorly, and runs upwards and laterally for its attachment to the medial side of the occipital condyle. Main action of theirs is to limit the rotation.

**Movements:** Nodding movement takes place between the atlas and the occipital bone. Rotatory movement occurs between the atlas and the axis, during which the skull along with the atlas moves round the axis.

# MOUTH

It is divided in two, the mouth proper and the vestibule. When the teeth are clenched two parts communicate behind the last motor. Roof of the mouth is formed by the hard and the soft palates and the floor by the tongue. Posteriorly it communicates with the pharynx through the oropharyngeal isthmus. Antero-laterally it is bounded by the teeth and the gums. Under the tongue following structures are seen – (1) Frenulum of the tongue, (2) Sublingual fold and papilla—one on either side, (3) Deep lingual veins, and (4) Fimbriated fold.

Examination of the oral cavity shows the palatoglossal arches running from the palate above to the tongue below with oropharyngeal opening in between leading to the oropharynx. Tonsils may be seen posterior to the palatoglossal arches.

**Lips (Figures 239 to 241):** Lips are thick muscular folds covered with the mucous membrane from inside and the skin from outside. The meeting point of the skin and the mucous membrane is known as the edge of the lip. Core of the lip is formed by the orbicularis oris muscle and other small muscles. Lips meet laterally at the lateral angle of the mouth. Franulum a thick mucous fold connects the lip to the gums in the midline.

**Figure 239** Showing communication of vestibule of mouth behind the last molar

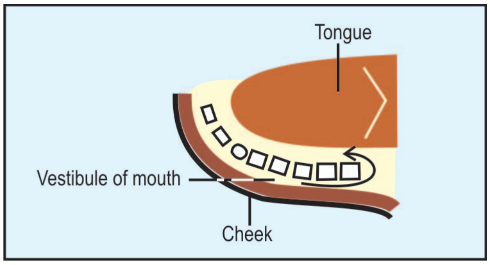
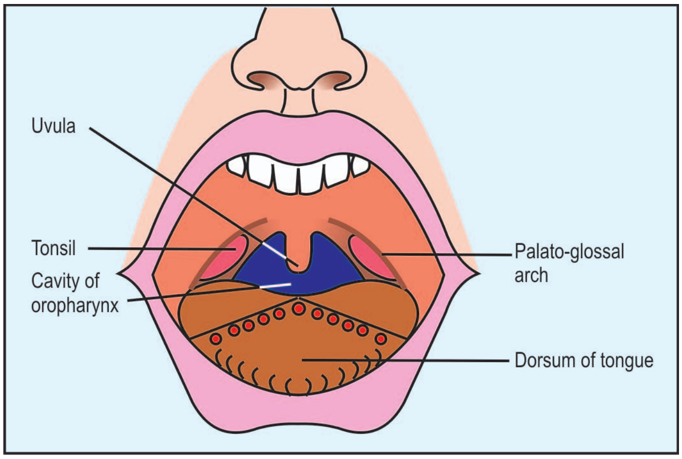



**Figure 240** Showing interior of mouth



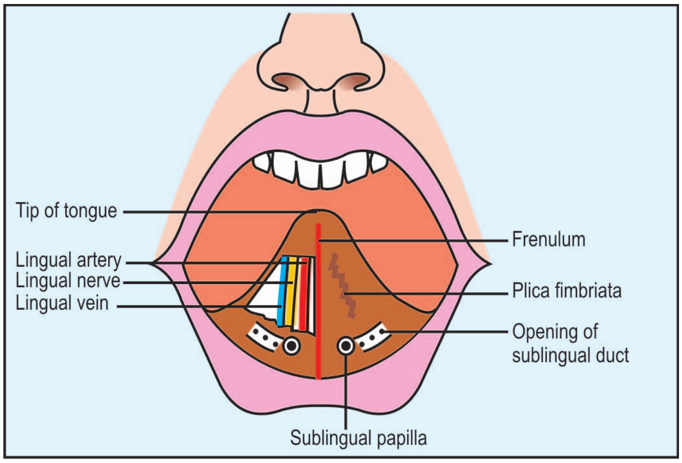



**Figure 241** Showing structures under the trunk

**Cheek:** It is made up of the skin, fatty tissue, buccopharyngeal fascia, buccinator muscle, submucous coat and the mucous membrane, arranged from lateral to the medial side.

**Gums:** They form the dense fibrous structure along the margin of both the jaws.

Gum has two parts—the fixed and the free. Free part surrounds the tooth like a collar. Fixed part is firmly attached to the jaws at the alveolar processes. Nerve supply of the upper gums comes from the naso-palatine and the superior alveolar nerves. The nerve supply of the lower gum comes from the inferior alveolar, lingual and the buccal. Buccal nerve supplies the outer part of the lower gums upto the mental foramen.

**Submucous Fibrosis:** Nice pink looking mucosa of the mouth becomes white due to the formation of fibrous tissue in the submucosa. Patient is not able to open the mouth and does not tolerate chilli. The condition of sub-mucous fibrosis is due to the so called pan masala, i.e. Ghutka. Unfortunately incidence of submucous fibrosis (SMF) is reaching the Himalayan heights. Submucous fibrosis may end in cancer.

**Development of the Upper Lip:** Lateral part of the upper lip is formed by the maxillary process along with the skin covering it. Muscular part is mesodermal and the skin is ectodermal. Medial part of the lip is formed by the fronto-nasal process, however the skin covering it is derived from the ectoderm of the maxillary process.

Explaining the nerve supply of the upper lip which comes from the maxillary nerve.

# THE TONGUE

Tongue is the inverted shoe-shaped muscular organ covered with stratified squamous epithelium situated in the floor of the mouth with its tip directed anteriorly and base posteriorly. It has the larger dorsal and the smaller ventral surfaces. Mucous membrane of the dorsum is thick and rough while the mucous membrane of the ventral surface is thin and smooth, as a result the deep lingular veins can be seen as a bluish structures running towards the tip. Dorsal surface is divided into anterior two-thirds, projecting in the oral cavity and the posterior one-third projecting towards the pharynx. The two parts of the tongue are well marked on its dorsum by a v-shaped sulcus known as the sulcus terminalis. At the apex of it is a small blind pit known as a foramen caecum (Blind). Posterior 1/3rd forms the anterior wall of the oro-pharynx.

**Dorsal Surface (Figure 242):** Immediately in front of the attachment of the palatoglossal arch a few vertical folds are seen in the mucous membrane at the lateral margins of the tongue and they are known as the folia linguae. Mucous membrane of the dorsum of the pharyngeal part is studied with low elevations. These are due to the presence of the lymph follicles (lingual tonsil). Lingual tonsils are the members of the Waldyer's ring.

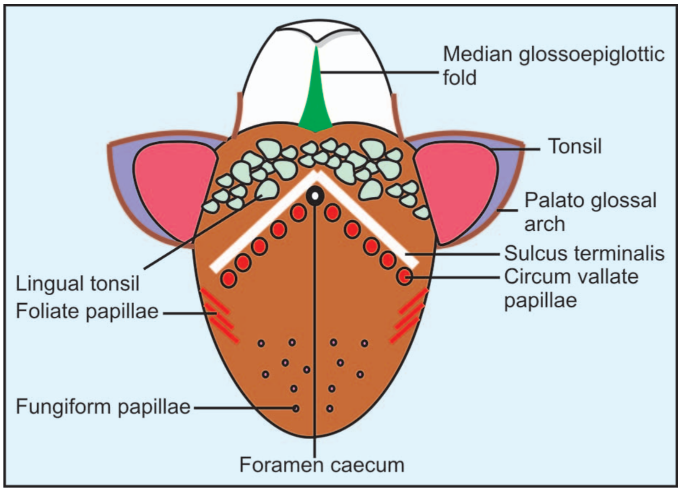



**Figure 242** Showing dorsum of tongue

**Waldyer's Ring (Figure 243):** It is the name given to the collection of lymphoid tissue. They are the palatine, lingual, tubal and the adenoids found around the pharynx inside. The outer ring of the Waldeyer's consists of given to the group of lymph nodes outside the pharynx such as sub-mental, sub-mandibular, pre-auricular and post auricular and the occipital.

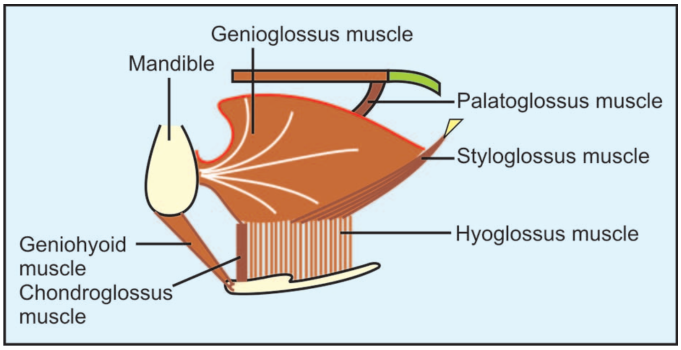



**Figure 243** Showing extrinsic muscles of tongue

A median fold of mucous membrane runs from the tongue to the epiglottis is known as the median glossoepiglotic fold. The mucous membrane of the oral part of the tongue shows the vallate, fungiform, and the filiform papillae. Vallate papillae are 8 to 12 in number, placed in front of the sulcus terminalis. They are surrounded by a trench all around, the walls of which present taste buds.

Fungiform papillae are near the tip and margin while the filiform papillae occupy the rest of the ventral surface of tongue. A fold of mucous membrane which runs from the tip and under surface of the tongue to the floor of mouth is known as frenulum. By the side of the frenulum nearer the tip, are the mucous and serous glands of Blandin and Nuhn. Deep lingular veins are seen on either side of frenulum, and lateral to it are the plica fimbriata. In the floor of mouth under the tongue are the sublingual papillae where the submandibular ducts open. Lateral to the papillae are the whitish folds on which the ducts of the sublingual gland open.

**Muscles of the Tongue: Extrinsic and Intrinsic:**

They are divided in two groups:

Following muscles are in extrinsic group are as under:

1. Genioglossus,
2. Hyoglossus,
3. Styloglossus
4. Palatoglossus, and
5. Chondroglossus.

They arise from outside the tongue and get inserted into the tongue. Description of all the muscles except palatoglossus is already given. However, it is pertinent to revise at this stage.

Extrinsic muscle of tongue

| *Sr. No.* | *Name* | *Origin* | *Insertion* | *Action* | *Remarks* |
|---|---|---|---|---|---|
| 1 | Genio-glossus | Superior genial tubercle of mandible. | Tip and the dorsum of tongue and hyoid bone | It protrudes the tongue | In case of injury of the hyoglossal nerve the tip of the tongue is deviated to the side of the lesion due to unopposed action of the medial fibres of the muscle on normal side. |
| 2 | Hyo-glossus | Body of hyoid and the greater cornu | Side of the tongue | Depression of the tongue | |
| 3 | Palato-glossus | Under surface of the palatine aponuerosis | Inserted into the side of tongue posteriorly. | Pulls the tongue towards the palate. | It is the only muscle of the tongue which is not supplied by the hyoglossal nerve, being the muscle of palate it is supplied by the cranial root of the accessory nerve. |
| 4 | Chondro-glossus | It is in fact the part of the Hyoglossus muscle | | | Supplied by the hyoglossal nerve. |

**Note :** All the muscles of the tongue intrinsic and extrinsic are supplied by the hypoglossal nerve except the extrinsic muscle the palatoglossus which being the muscle of palate is supplied by the cranial root of accessory. All the muscles of the palate are supplied by the cranial root of accessory except the tensor palatii, which is supplied by the mandibular nerve.

**Palatoglossus :** It arises from the under surface of the palatine aponeurosis runs downwards, forwards, laterally in front of the tonsil and gets inserted into the side of the tongue where it blends with the fibres of the transverse linguae muscle.

**Nerve supply :** Being the muscle of palate it is supplied by the cranial root of the accessory.

**Action:** It raises the root of the tongue upwards and backwards.

**Intrinsic muscles of the tongue:** They have no external attachment and are limited to the tongue itself.

1. *Superior longitudinal muscle (Figure 244):* Covers the dorsum of the tongue and lies under the mucous membrane.

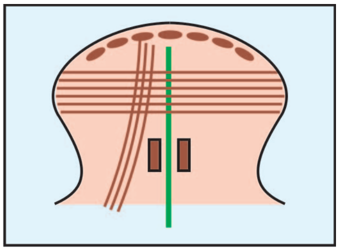


**Figure 244** Showing intrinsic muscles of the tongue

2. *Inferior longitudinal muscles are in a pair:* Each lies lateral to genioglossus and is situated between the tip of the tongue and the hyoid.
3. *Transverse muscles :* They are present under the superior longitudinal fibres. Fibres run from the septum to the side of the tongue.
4. *Vertical muscles:* They run downwards and laterally towards the lower part of the tongue. They are seen decussating with the fibres of the transversus.

**Septum of the tongue:** Septum of the tongue is the median fibrous partition of the tongue attached to the hyoid bone posteriorly. It is separated from the dorsum of the tongue by the superior longitudinal fibres as the septum fails to reach the dorsum of the tongue above. Posteriorly it is thick and is attached to the root of the tongue and the hyoid bone. It is known as the hypoglossal membrane.

## Nerve Supply of the Tongue

**Anterior two thirds:** Mucous membrane of the anterior 2/3rd of the tongue is supplied by the lingual nerve (general sensation) and the chordatympani (taste sensation). Posterior one-third of the tongue including the circumvallate papillae is supplied by the glossopharyngeal nerve both the general and the special sensation of the taste.

**Beer drinker's nerve:** Posterior most part of the pharyngeal surface of tongue is supplied by the internal laryngeal nerve. Internal laryngeal nerve is also known as beer drinker's nerve as the beer is tasted at the posterior most portion of the tongue.

**Blood supply:** The lingual artery the branch of the external carotid artery is the chief artery supplying the tongue through dorsal and the deep branches. Inferior alveolar artery, the branch of first part of the maxillary also supplies the tongue.

**Lymphatic drainage of the tongue (Figures 245 and 246)**

Higher incidence of the cancer of the tongue makes lymphatic drainage of the tongue important. It is arranged into three groups—the submental, submandibular and the deep cervical nodes.

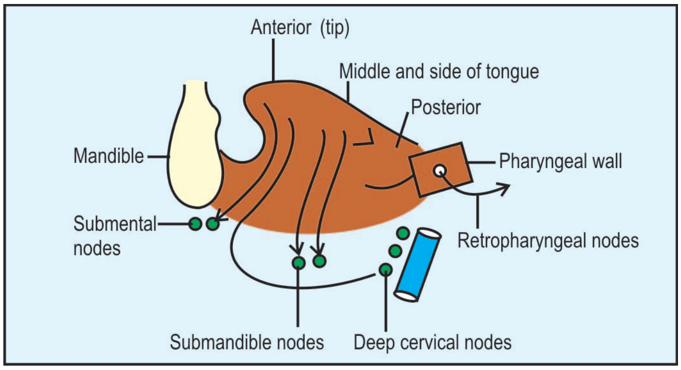



**Figure 245** Showing lymphatic drainage of tongue

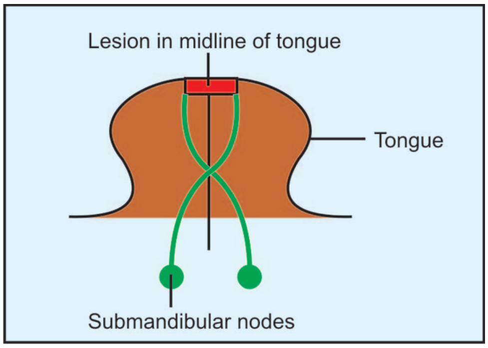



**Figure 246** Midline zone of the tongue has by lateral lymphatic drainage. Therefore midline carcinoma of tongue spreads to both the sides (Fortunately midline cancer of tongue is rare)

Numerous lymph vessels from the tip of the tongue drain bilaterally in the submental lymph nodes. However, some reach jugulo-digastric nodes.

Central lymph vessels from the midline pass downwards through the core of the tongue and end in the jugulo-digastric group of both the sides.

Lymphatics from the lateral part of the anterior 2/3rd of the tongue go to the submandibular nodes.

Lymphatics from the posterior 1/3rd of the tongue go mainly to the jugulo-digastric and to the jugulo-omohyoid nodes. Some of the lymphatic channels from the posterior 1/3rd of the tongue may go to the retropharyngeal nodes.

**Development of the tongue (Figure 246A):** The tongue develops from two sources, anterior two-third from the first arch and the posterior 1/3rd from the third. In the region of the first arch the median swelling appears. It is known as the tuberculum impar. Two lingual swellings appear by the sides of the tuberculum impar. In the region of the 3rd arch hypobranchial eminence appears in the middle and gets divided into the anterior and the posterior parts. Anterior part joins the developing the tongue to form the posterior 1/3rd of the tongue. The remaining posterior part of the hypobranchial eminence forms the epiglottis. Muscles of the tongue are developed from the occipital myotomes which migrate from the occipital region to the tongue. This explains the course of the hypoglossal nerve.

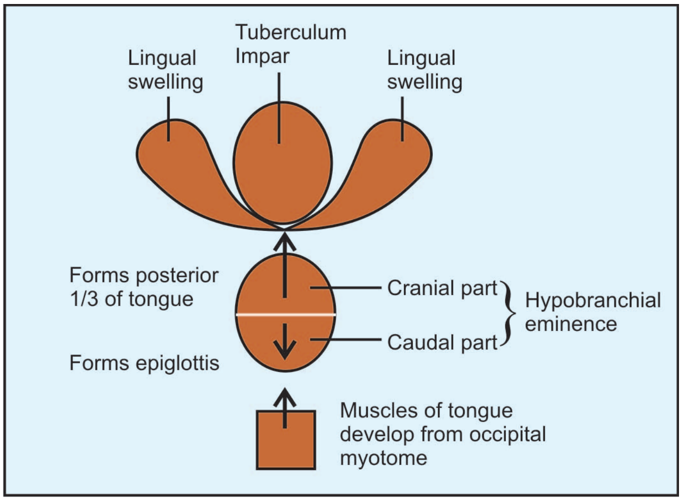



**Figure 246A** Showing development of tongue

Posterior most portion of the tongue develops from the fourth arch and is supplied by the internal laryngeal nerve the branch of the superior which itself is the branch of the vagus.

**Clinical: Anomalies of the tongue:**

1. Tongue tie: It may restrict the movements of the tip of the tongue and one finds it difficult to clean the back of the incisors. Normally it does not interfere with the functions of the tongue, such as that of the taste, speech, mastication and the swallowing. In case of the severe degree of the tongue tie, the frenulum is cut.
2. Macroglossia
3. Bifid tongue
4. Lingual thyroid
5. Thyroglossal cyst
6. Fissured tongue
7. Trifid tongue
8. Glossitis
9. Bald tongue of anaemia
10. Trauma – bleeding
11. Fall-back of tongue in the bilateral fracture in the body of the mandible.

**Carcinoma of the tongue:** Carcinoma of the tongue commonly occurs at the lateral margin, i.e. 47% and the next popular site is the posterior 1/3rd of the tongue. The patient of carcinoma of tongue has pain in the tongue, salivation and ankyloglossia–patient is not able to protrude the tongue. Dysphagia–difficulty in swallowing particularly in the carcinoma from the posterior 3rd of the trunk. Patient is unable to speak properly. Lump in the neck due to the secondaries in the lymph nodes. At times change in the voice is the first indication of the carcinoma of the posterior third of the tongue.

**Macroglossia:** The hamartomas of the tongue can result in painless enlargement of the tongue. It is large in proportion to the oral cavity. Acquired causes of the enlarged tongue are acromegaly and amyloidosis.

**Cretinism:** In hypothyroidism the tongue is enlarged due to occumulation of mucoproteinous material in the tongue.

**Laceration of the tongue:** Laceration of the tongue occurs in persons suffering from epilepsy. Fracture of the mandible can also cause a laceration of the tongue. Due to the damage to the lingual artery severe haemorrhage can occur in the injury of the tongue. The bleeding can be arrested by hooking the tongue forwards with the finger and compressing the tongue against the mandible between the finger and the thumb. As the tongue has an extensive blood supply it

can be sutured which results in early and sound healing. Close injury of the tongue occurring due to the fracture of the mandible can lead to haematoma which spreads in the tongue and the floor of the mouth. It causes respiratory obstruction requiring urgent tracheostomy.

**Fracture of the mandible:** In bilateral fracture of the body of the mandible the tongue looses its anchorage to the mandible and falls back. It is known as the falling back of the tongue.

It can result in respiratory obstruction.

Importance of clinical examination of the tongue:

1. Smooth tongue (Bald or plain) is seen in iron deficiency anaemias.
2. Coated furred tongue is seen in patients suffering from prolonged illnesses.
3. Coated tongue with red margin and headache is a classical presentation of enteric fever,
4. Glossitis inflammation of the tongue is known as glossitis it can be acute or chronic.

# PHARYNX

Pharynx is the fibro-musculo-membranous tube extending from the base of the skull to the level of 6th cervical vertebra, and the cricoid cartilage, where pharynx ends and oesophagus begins. Its length is about 12 to 14 cm and its greatest width is 3.5 cm (At the base of skull behind openings of the auditory tubes). Is reduced to 1.5 cm at its junction with the oesophagus. It is the narrowest part of the alimentary canal. (Only comparable to the opening of the lumen of the appendix). Normally it is compressed antero-posteriorly presenting the anterior and the posterior surfaces and the lateral borders. Superiorly it is bounded by the body of sphenoid and the basilar part of the occipital bone. Posteriorly it is supported by the cervical portion of the vertebral column. Pharynx has three part upper, middle and the lower. The upper part opens into nasal cavity anteriorly and is known as the nasopharynx. The middle part opens in to the oral cavity anteriorly and is known as the oropharynx. Lower part lies behind the larynx and is known as the laryngeal part of the pharynx. The pharynx has complete posterior wall however the anterior wall shows regular interruptions by the openings (Figures 247 and 248).

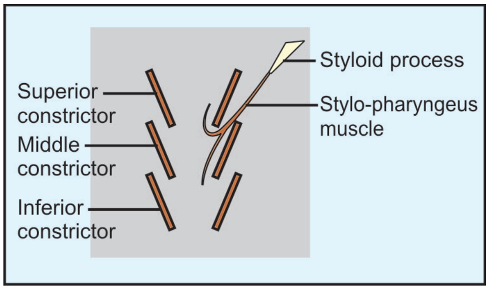



**Figure 247** Showing arrangement of constrictors of pharynx and stylo-pharyngeus muscle

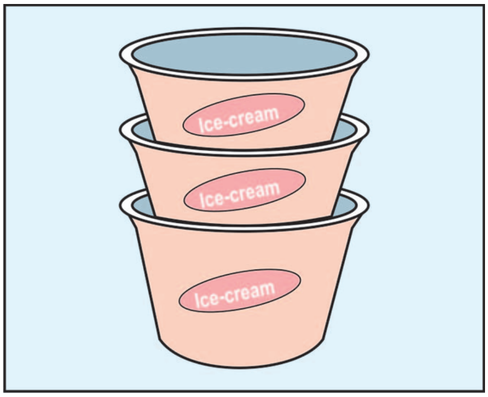



**Figure 248** Showing arrangement of pharyngeal muscles like paper cones of ice-cream

**Pharyngeal wall:** It is made of following layers from without inwards

1. Bucco-pharyngeal fascia.
2. Pharyngeal muscles,
3. Pharyngo-basilar fascia,
4. Sub-mucous coat,
5. Mucous membrane.

**Constrictor muscles:** The arrangement of the three constrictors is like three paper cones. They are superior, middle and the inferior constrictors.

**Superior Constrictor (Figure 249):** Superior constrictor arises from the posterior border of the medial pterygoid plate, pterygoid hamulus, pterygomandibular raphae, posterior part of mylohyoid line of mandible, mucous membrane of mouth and the side of the tongue. After origin, fibres curve backwards, medially and upwards to reach the median raphe. Some of the fibres are inserted into the pharyngeal tubercle. The space between the base of the skull and the upper border of the superior constrictor muscle is filled by the pharyngo-basilar fascia. The space is known as the sinus of Morgangni. In the space are the auditory tube, the tensor palati anterior to the tube and the levator palati posterior. Lower part of the superior constrictor muscle is overlapped by the fibres of the middle constrictor. The gap between the superior and the middle constrictor muscles provides passage to the stylopharyngeus muscle and the glossopharyngeal nerve.

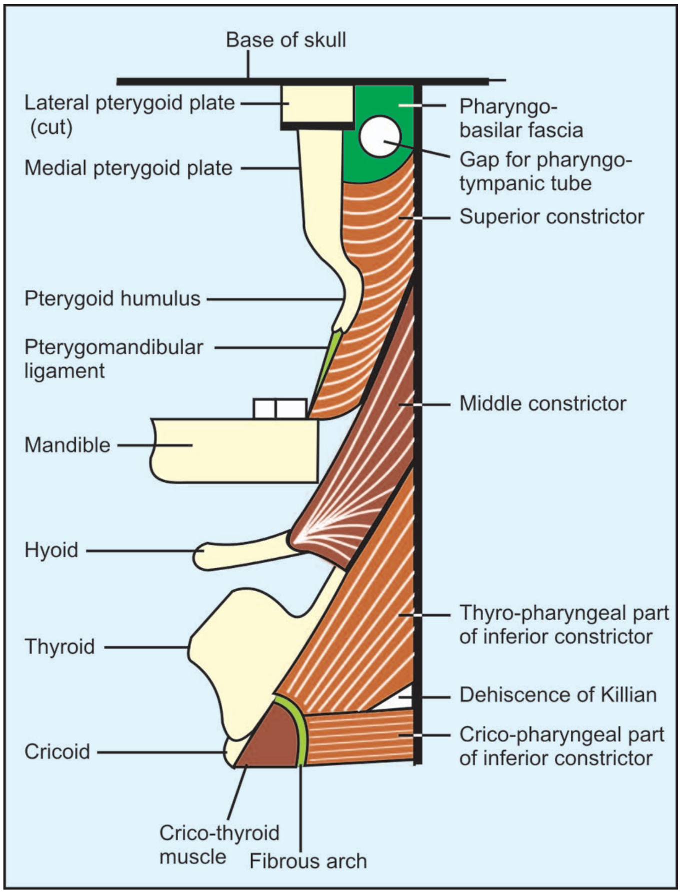



**Figure 249** Showing muscles of pharynx side view. Note origin of three constrictors and their arrangement like paper cones

**Pharyngo-basilar Fascia (Figure 250):** Pharyngo-basilar lies between the pharyngeal muscles and the submucous coat. It has already been stated that it is stronger and it fills up the space above the superior border of the superior constrictor muscle. It is pierced by the pharyngotympanic tube.

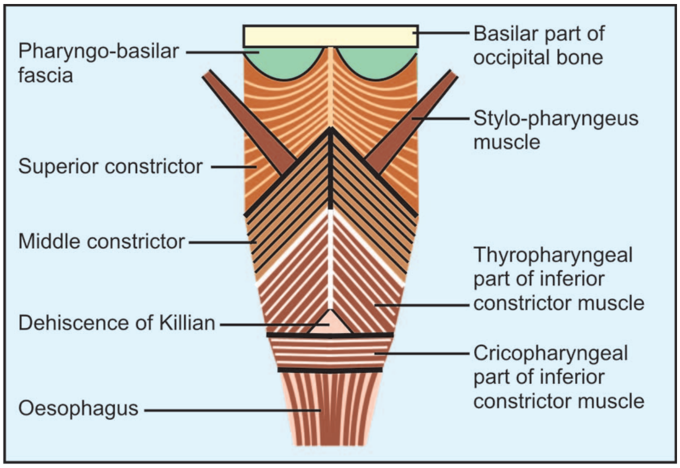



**Figure 250** Showing muscles of pharynx viewed from behind

**Middle Constrictor:** It arises from the stylohoid ligament, lesser cornu and the body of the hyoid bone. Fibres pass towards the median raphe in a fan shaped manner. Upper fibers ascend, lower one descend and the middle fibers choose the horizontal course.

**Inferior Constrictor:** The muscle has two parts:

1. Thyropharyngeus and the
2. Crico-pharyngeus:

   Thyropharyngeus part arises from the oblique line of the thyroid cartilage and ascends upwards. Crico-pharyngeal part arises from the fascia covering the cricothyroid muscle and the side of arch of the cricoid cartilage. These fibres run horizontally. They meet the fellow of the opposite side in the mid-line posteriorly. There is a space between the two groups of fibers posteriorly. It is the weak spot known as "the gateway of tear", since perforation can occur at the spot during oesophagoscopy with a rigid oesophagoscope. Herniation of the mucosa can occur here where the pharyngeal mucosa comes out forming the phyryngeal diverticulum. This weak spot is also known as Dehiscence Killian's. Cricopharyngeal part acts as the sphincter secondary to the cardiac. It is closed most of the time except during the phase of deglutition, when it relaxes and the thyropharyngeal part contracts. If the cricopharyngeus fails to relax and thyropharyngeus contracts the pressure in side the pharynx rises resulting in the herniation of the mucosa. It is known as pharyngeal pouch or diverticulum.

**Longitudinally Arranged Muscles:** They are three (1) Stylopharyngeous, (2) Palatopharyngeous and (3) the salpingo-pharyngeous. Stylopharyngeous arises from the styloid process near the base, palatopharyngeous arises from the superior surface of the platine aponeurosis and salpingo-pharyngeous arises from the tubal elevation in the lateral wall of the pharynx. All three muscles are inserted into the posterior border of the lamina of the thyroid.

**Role of Longitudinal Muscles:** Constrictors by serial contractions in the transverse direction push the bolus of the food downwards. The longitudinal muscles pull the pharynx upwards and further helps the bolus to go downwards. It is like filling of a gunny bag with the grain when the bag is pulled vertically upwards which helps the grain to go downwards.

**Passavent Muscle:** Passavent muscle is the part of the palatopharyngeous muscle. Instead of going down some fibres remain at the level of the palate encircles the superior constrictor from inside. It becomes prominent during the closure

of pharyngeal isthmus. In cases of the cleft palate the muscle gets hypertrophied and form an ridge known as the Passavant's ridge.

**Nerve Supply of the Constrictors:** Constrictors of the pharynx are supplied by the pharyngeal plexus. (nucleus ambiguous). The stylopharyngeous muscle is supplied by glossopharyngeal nerve. The palatopharyngeal is supplied the cranial roof of the accessory, being the muscle of palate.

**Nasopharynx:** It must be remembered that it is respiratory function. It is the highest, widest and non-collapsible part of the pharynx, situated behind the nasal cavity. Roof is formed by the body of the sphenoid and the basilar part of the occipital bone. Anteriorly it opens into the posterior apertures of the nasal cavities. Each posterior opening of the nasal cavity is 25 mm vertically and 12.5 mm transversely. The cavities are separated by the posterior edge of the nasal septum. Each of half of the nasal cavity shows the middle and the inferior nasal conchae.

**Lateral Wall of the Nasopharynx: (Figure 251)** Lateral wall of the nasopharynx has an opening, of the pharyngotympanic tube which connects it to the middle ear. Opening of the pharyngotympanic tube is situated 1.25 cm behind and below the posterior end of the inferior concha.

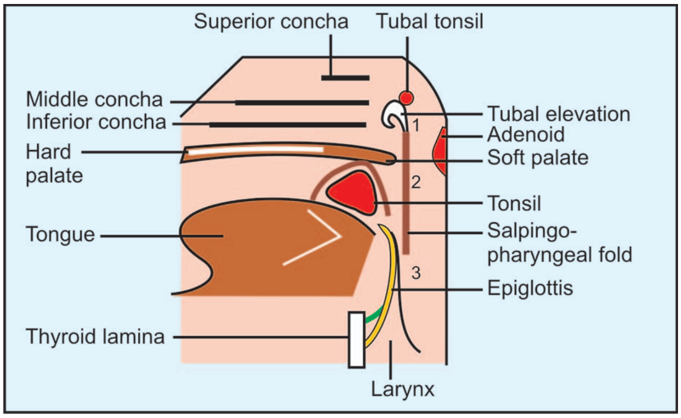



**Figure 251** Showing interior of pharynx naso, oro and laryngeal part of pharynx from above downward labled as 1, 2, 3

Connection of the nasopharynx with the middle ear cavity helps in equalizing the pressure in the middle ear and the atmosphereic pressure. It provides fresh air to the middle ear. This opening is bounded, by the rounded margin of the triangular cartilage has its apex laterally and base medially it is folded in such a way that its medial lamina is more than the lateral. The remaining wall is completed by the fibrous tissue. At the junction of the medial and the lateral laminae is the elastic tissue which permits movements between the two lamini. Anterolateral to the pharyngotympanic tube is the collection of fat known as OTSMAN pad of fat which allows free dilatation of the pharyngotympanic tube when required. The tubal tonsils are situated postero-superior to the opening of the pharyngotympanic tube. It belongs to the inner ring of Waldyer along with the palatine tonsil, lingual tonsil and the adenoids. Immediately above the opening of the pharyngotympanic tube and the tubal tonsil is depression known as the pharyngeal recess. It is also known as the fossa of Rosenmuller's. It is the commonest site for the malignancy of the nasopharynx. Running from the tubal elevation downwards is the fold of mucous membrane known as the salpingopharyngeal fold which contains the salpingopharyngeal muscle. At the junction of the roof and the posterior wall of the nasopharynx is the collection of lymphoid tissue known as pharyngeal tonsils or adenoids. In the centre of it lies a bursa which is

known as the pharyngeal bursa. Inflammation of the pharyngeal bursa is known as pharyngeal bursitis. When infected it can form an abscess. The site of bursa developmentally corresponds to the anterior attachment of the notochord. Above the adenoid there is slit like opening which is the remnant of Rathke's pouch. Malignant tumor may arise from the cells of the Rathkey's pouch. The roof of the nasopharynx may communicate with the fossa for the hypophysis cerebri in the sphenoid bone through the cranio-pharyngeal canal. At times it gives origin to the secondary hypophysis when the functions of primary are failing. Tumors arising from the pharyngeal canal are known as craniopharyngiomas. The lymphoid tissue in the adenoid belongs to mucosa associated lymphoid tissue (MALT).

Overlying mucosa of the adenoids is thrown into radiating folds. Adenoids increase in size upto the age of 6 years thereafter it undergoes an atrophy. Formation of an abscess in the pharyngeal bursa is known as 'Thorwald's disease'. It may present as the fluctuating swelling in the midline on the posterior wall. It is bounded above and behind by the tubal elevations. Postero-superior to the tubal elevation is the tubal tonsil. Above and behind the tubal elevation is a small recess which is known as fossa of Rosenmuller (Pharyngeal recess). It is the commonest site for the carcinoma of nasopharynx. The recesses is the remnant of the Rathke's pouch, which forms anterior lobe of the pituitary. Rathke's pouch may form the craniopharyngeal canal.

*Effects of adenoids:*

1. As the enlarged adenoids block the nasopharynx, mouth breathing becomes eminent.
2. High raised palate.
3. Atrophy of the alae of the nose.
4. Sleep apnoae.
5. Adenoid facies : It occurs due to the day time nasal obstruction.
6. Blockage of the eustanchian tube leads to recurrent otitis media or secretory otitis media.

**Note :** Prominent posterior margin of the opening of the pharyngo-tympanic tube acts as the guide for the ENT surgeon during introduction of the eustanchian catheter (Tauras tubaris).

**Floor :** It is formed by the soft palate anteriorly and the opening between the nasopharynx and the oropharynx. Posteriorly it is known as the nasopharyngeal isthmus. Free posterior margin of the soft palate comes in contact with the pharyngeal wall and helps in closing the opening. Passavant's muscle is the part of the palatopharyngeus muscle which runs horizontally at the level of the palate internal to the superior constrictor muscle. When hypertrophy it is known as the Passavant's ridge. It is prominent and well developed in cases of the cleft palate.

## Clinical

**Posterior Rhinoscopy:** It is done with the rhinoscopic mirror with the tongue pressed down. As the mirror reaches posterior 1/3 of the tongue light from the head mirror is focused on the rhinoscopic mirror. This eluminations the nasopharynx. Through this procedure interior of the nasopharynx can be examined. It shows, the inferior, the middle conchae, nasal septum, soft palate, uvula, opening of pharygotymphanic and the fossa of Rosenmuller.

**Carcinoma of the Pharyngotympanic Tube:** Rosenmuller's fossa is the commonest site for the carcinoma of the nasopharynx. The malignant growth may infiltrate into the cranial base which may lead to the involvement of the cranial nerves. Direct spread through the foramena lacerum, carotid canal, jugular foramen and the foramen ovale leads to intracranial extensions. Spread to the eustachian tube leads to conductive deafness. Extension of the cancer to the nasal cavity causes the bleeding through nose (epistaxis). Distant spread of the cancer to the retropharyngeal and the deep cervical nodes are well-known.

**Functions of Nasopharynx:**

1. To supply humid and warm air to the larynx and the trachea.
2. With the help of eustachian tube it equalizes the pressure on both sides of the tympanic membrane. Its function is important for hearing.
3. Elevation of the soft palate closes the nasopharyngeal isthmus during swallowing, vomiting and speech.
4. It acts as the resonating chamber during the production of the voice. Nasopharyngeal obstruction leads to the disorders of the voice.
5. It acts as the drainage outlet for the secretions of the nasal and nasopharyngeal glands.

**Oropharynx :** Anteriorly it is the mouth and the dorsum of the tongue. Behind the tongue lies the epiglottis with a median glosso-epiglottic fold and the valecullae on either side. Lateral glossoepiglottic fold is on the lateral side of the valeculla. Lateral wall of the oropharynx presents the tonsillar fossa which is bounded above by the palate below by the tongue anteriorly by the palatoglossal and posteriorly by the palatopharyngeal arches. Palatine tonsil is situated in the tonsillar fossa at the oropharyngeal isthmus.

## Boundaries of the Oropharynx

**Posterior Wall:** It is related to the retropharyngeal space and lies opposite the second and the upper part of the third cervical vertebrae.

**Anterior Wall:** Anterior wall has an opening of the oropharynx. If viewed from behind following structures are seen:

(1) Base of the tongue, (2) lingual tonsils, (3) vallecule.

Each valleculus is bounded medially by the median glosso-epiglotic fold and laterally by the pharyngoepiglotic folds. It is the common site for retention cysts.

**Lateral Wall:** Lateral wall presents palatine tonsil in the tonsiller fossa which is bounded by the palate above, tongue below, palatoglossal arch anteriorly and the palatopharyngeal posteriorly. Palatoglossal arch is formed by palatoglossus muscle and the palatopharyngeal arch is formed by the palatopharyngeus muscle. Two arches almost form an upright triangle having base below and the apex above. The triangular depression thus formed is known as the tonsillar fossa. Tonsillar fossa is bounded laterally by the superior constrictor muscle and supplemented by the styloglossus.

**Lymphatic Drainage of the Oropharynx:** Lymphatics from the oropharynx drain into the upper jugular chain of lymph nodes known as jugulodigastric. Base of the tongue drains into the retropharyngeal nodes and also in the jugulodigastric. Lymphatics from the base of the tongue may go to the nodes on either side.

**Functions of Oropharynx:**

1. Acts as a passage for air and food.
2. Helps in pharyngeal deglutition.
3. Helps in speech.
4. Appreciation of the taste.

5. Taste buds are present at the base of the tongue, anterior pillar, posterior pharyngeal wall and the soft palate.
6. Provides defense as it is the member of the inner ring of Waldyer's. Lymphocytes in the germinal sites of the follicles produce antibodies.

**Hypopharynx: (Laryngopharynx)** Hypopharynx is the lowest part of the pharynx situated behind the larynx. It is limited superiorly by the line joining the body of the hyoid to the posterior pharyngeal wall, however, its lower limit is indicated by the cricoid cartilage which lies at the 6th cervical vertebra. Here hypopharynx ends and the oesophagus begins. Hypopharynx is situated opposite to the 3, 4, 5, 6 cervical vertebrae (All the vertebrae, i.e. 3, 4, 5, 6 are the typical cervical vertebrae). Hypopharynx is divided into three regions.

1. Piriform fossa
2. Post cricoid region
3. Posterior pharyngeal wall

**Piriform Fossa: (Figure 252)** It is situated between the aryepiglottic fold medially, thyrohoid membrane and the thyroid cartilage laterally. Although it forms the lateral channel for the food, foreign bodies get lodged in the piriform fossa. The mucous membrane of the piriform fossa is supplied by the internal laryngeal nerve. The fossa is also known as the smugglers fossa as before the advent of the X-rays. Smugglers used to hide valuable articles like gold and dimonds in the piriform fossa. Internal laryngeal nerve runs in the lateral wall of the fossa below the mucous membrane and supplies it. Here it can be anaesthetized by the local anaesthetic agent.

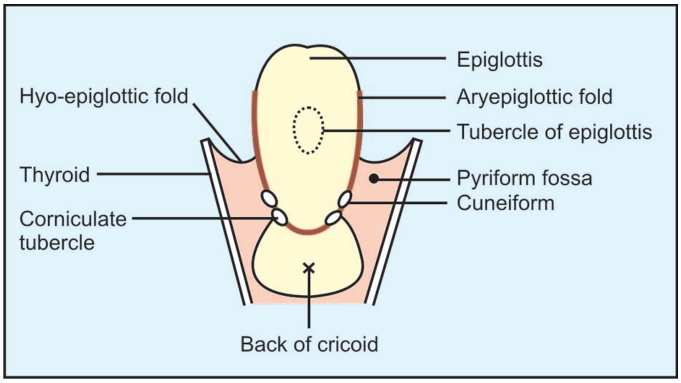



**Figure 252** Showing view of the anterior wall of laryngeal part of pharynx

**Note:** Internal laryngeal is known as Beer driker's nerve.

**Post-cricoid Region:** It lies between the upper and lower borders of the cricoid lamina. It is the common site for malignancy in female with severe anaemia, which is known as post-cricoid carcinoma (Plummer-Vinson's syndrome).

# TONSIL

They are the paired almond shaped masses of lymphoid tissue at the oropharyngeal isthamus between the palatoglossal and palatopharyngeal arches. Tonsils are almond shaped paired mass of a lymphoid tissue situated between the palatoglossal and the palatopharyngeal arches at the oropharyngeal isthmus. Its upper pole reaches the palate and the lower broad end touches the tongue. Its lateral surface is convex and is covered with the incomplete facial capsule. Outside the facial capsule lies the loose areolar space containing the large vein known as the paratonsillar vein which descends from the palate. It is the plane of dissection for removal of the tonsil. Tearing of the paratonsillar vein during operation results in troublesome bleeding. The lateral relations of the tonsil are the superior constrictor, styloglossus muscles and the facial artery with its ascending palatine branch. The internal carotid artery lies 2.5 cm postero-lateral to the tonsil in the parapharyngeal space. Long styloid process reaches the lateral surface of the tonsil and can be felt by palpation. Medial surface of the tonsil presents numerous crypts lined by non-karatinising type stratified squamous epithelium. Crypts are situated deep in the substance of the tonsillar mass and present secondary tonsillar crypts. In acute follicular tonsilar crypt are filled with pus and appears as yellow spots on the congested to medial tonsillar wall. Anteroinferior part of the medial surface of the tonsil is covered with a fold of mucous membrane known as the plica triangularis. It runs from palatoglossus arch to the tongue (Figure 253).

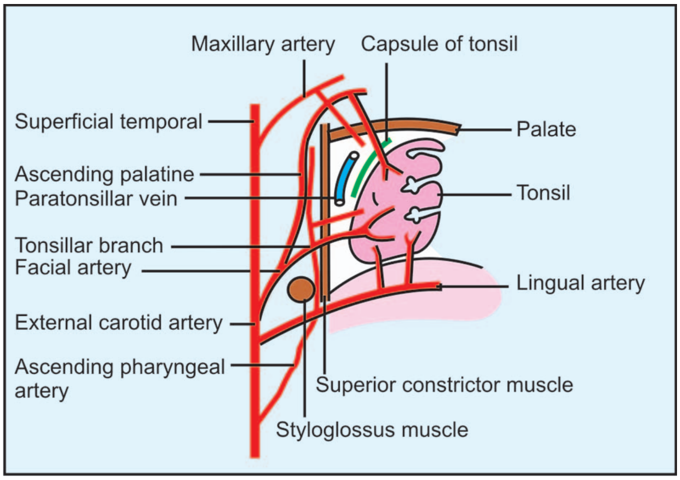



**Figure 253** Cross-section showing walls of the tonsillar fossa. Blood supply of tonsil is also shown. Please note that the ascending pharyngeal artery is the lowest branch of external carotid artery

**Blood Supply:** Tonsil is supplied mainly from the tonsillar branch of the facial artery. It receives blood supply from the lingual, the ascending palatine, ascending pharyngeal and the branch from the maxillary artery.

**Venous Drainage:** Venous drainage of the tonsil enters the pharyngeal plexus or unite to form of the single stem and joins the common facial vein.

**Lymphatic Drainage:** Lymphatics go to the nodes situated along the internal jugular vein and the common facial vein. Normally these nodes lie a little below and behind the angle of the mandible. These nodes should be palpated for evidence of tonsillar infections and not the submandibular lymph nodes as it is done by the majority of the practitioners.

**Nerves:** It is supplied by the 9th and the lesser palatine nerves.

**Histology:** It has lymphoid tissue having follicles. Each of the follicles has the germ centre in the centre where lymphocytes are packed less closely. Grypts are lined by stratified squamous epithelium. There are no peripheral lymph sinuses in the tonsil nor there are afferent lymphatics. Tonsil has only efferent lymphatics reaching the jugulodigastric group of nodes.

**Development:** Tonsil is endoderm in origin and develops from 2nd pharyngeal pouch. Its lymphoid tissue is derived from the mesoderm.

**Clinical:** Inclications for removal of tonsils.

Local - Chronic tonsillitis.

Focal - Chronic involvement of jugulodigastric node.

General - When it acts as the focus of infection.

**Note:** Generally tonsillectomy is contraindicated before the age of 5 years due to its immunological role.

1. Collection of pus outside the capsule of the tonsil is known as parietonsillar abscess (Quinsy).
2. For arresting the post tonsilectomy bleeding from tonsilar bed removal of the clot from the tonsilar fossa is the main first-aid measure. As the tonsillar fossa is emptied, the walls of the tonsillar fossa get collapsed, throtlling the bleeding vessels.
3. Laryngeal oedema.
4. Retropharyngeal or parapharyngeal abscess. In parapharyngeal abscess there is trismus and swelling on the lower part of the parotid which are missing in Quinsy. It occurs after tonsillectomy done under the local anaesthesia.
5. Acute otitis media.
6. Septic focus in rheumatic heart.
7. Acute tonsillitis is the inflammation of the tonsil due to infection.
8. Acute follicular tonsillitis presents pus in the tonsillar crypts which appear as yellow spots on the red tonsillar surface.
9. Tonsilloliths –It is due to calcification of the trapped pus in the tonsillar crypts. It is hard to touch and can be mistaken for the long styloid process.
10. Pain of acute tonsillitis is referred to the ear due to the common nerve supply from the glossopharyngeal nerve.

**Laryngeal Part of the Pharynx:** Anterior wall presents the inlet of the larynx, piriform fossa on either side of the inlet and the mucous membrane covering the posterior aspect of the arytenoid and cricoid cartilages. Inlet is bounded in front by epiglottis, aryepiglottic fold at the sides and the interarytenoid fold posteriorly Aryepiglottic fold contains aryepiglottic muscle. Near the lower end it has small nodes namely the cuneiform and the corniculate tubercles on either side produced by cuneiform and corniculate cartilages. Cuneiform being lateral and corniculate medial.

**Pyriform Fossa:** It has already been described.

# PALATE

Palate is the horizontal partition between the nasal cavity above and the oral cavity below. It is made up of two parts, the hard palate and the soft palate. Hard palate is formed by the palatine process of maxillae and the horizontal plates of the palatine bones. Posterior border of the hard palate has the spine which is known as posterior nasal spine.

**Soft Palate (Figures 254 and 255):** Soft palate runs backwards with the slight downward curve in the pharynx. It forms the mobile floor of the nasopharynx. It is attached to the posterior border of the hard palate. Posteriorly it presents the conical projection known as the uvula. Unusually long uvula comes in contact with the posterior wall of the pharynx and produces irritation and cough. It is bounded by the alveolar margin anteriorly and laterally and joins the soft palate posteriorly. Running down from the under surface of the soft palate are the anterior and the posterior arches respectively known as the palato-glossal and the palatopharyngeal arches.

**Figure 254** Showing muscles of palate (diagrammatic)

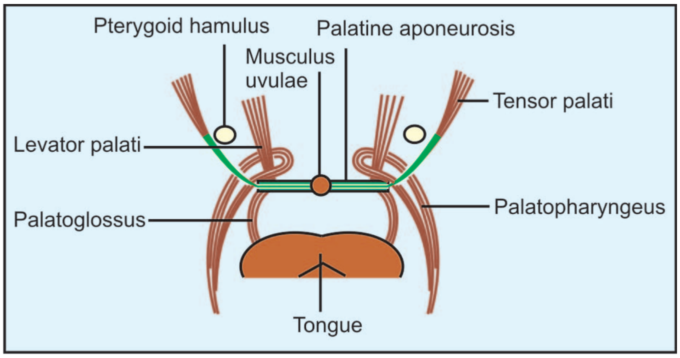
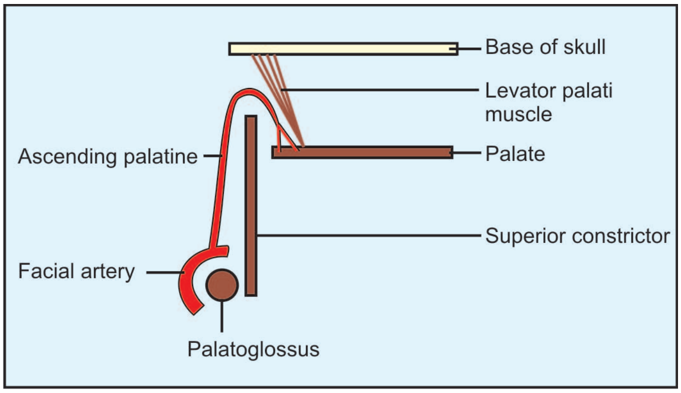



**Figure 255** Showing course of ascending palatine artery branch of facial




**Structure of the Hard Palate:** It is made up of bones covered with periosteum and the squamous type of mucous membrane. The mucous membrane has accessory salivary glands which may give rise to the ectopic salivary tumors.

**Structure of the Soft Palate:** It is made up of palatine aponeurosis, muscles, glands, blood vessels and nerves, all covered with the mucous membrane from above and below. Mucous membrane on the oral or the lower side is lined by the stratified squamous epithelium and towards the nasal side by the ciliated columnar epithelium. Palatine glands occupy the lower surface of the palate.

**Palatine Aponeurosis:** It is an expanded tendon of tensor palati muscle attached to the palatine crest. It occupies anterior two-thirds of the soft palate. It is thicker anteriorly. Anterior two-third of the soft palate is horizontal due to the palatine aponeurosis.

**Muscles:** Following are the muscles of the soft palate

1. Tensor palati,
2. Levator palati,
3. Palatoglossus,
4. Palatopharyngeus, and
5. The musculus uvulae.

**Palatoglossus:** At the palate, fibres are attached to the under surface of the palatine aponeurosis and some are continuous with the fellow of the opposite side. It descends lower down in the palatoglossal arch and gets inserted into the side of the tongue.

**Action:** The muscle draws the tongue towards the palate and closes the fauces. This prevents the regurgitation of food into the mouth from the pharynx.

**Tensor Palati:** Tensor palati arises from the scaphoid fossa, posterior margin of the foramen ovale, base of the spine of sphenoid and the lateral aspect of the pharyngotympanic tube. It runs downwards and forms a fine tendon which hooks the pterygoid hamulus, turns medially and enters the substance of the soft palate in the form of palatine aponeuroses.

**Action:** It is the tensor of the palate. If the pterygoid hamulus of either side is cut and the tendon is released and the tensor palati becomes the levator of the palati. Part of the tensor palati which arises from the pharyngotympanic tube is known as the dilator tube, as it opens the tube during its contraction.

**Nerve Supply:** It is supplied by the mandibular nerve through the otic ganglion.

**Levator Palati:** Levator palati arises from the apex of the petrous part of the temporal bone, the medial aspect of the pharyngotympanic tube and runs downwards and medially, crossing the upper border of the superior constrictor muscle of the pharynx, pierces the pharyngobasilar fascia and gets inserted into the superior surface of the palatine aponeurosis.

**Action:** It is the elevator of the palate.

**Glue Ear:** Tensor and levator palati muscles get atrophied in cases of the cleft palate, which affects the drainage capacity of the pharyngotympanic tube. Tube fails to clear the secretion in the middle ear, which collects in the middle ear and is known as Glue ear.

**Palatoglossus:** It has already been described along with the tongue.

**Action:** It approximates the palate and the tongue and helps in closure of the gap between the palatoglossal arches.

**Palatopharyngeus :** Palatopharyngeus arises from the superior surface of the palatine aponeurosis in two slip. Anterior slip is attached to the aponeuroses in front of the insertion of the levator palati, while the posterior slip is attached posterior to insertion of the levator palati. In other words two slips of the muscle enclose the insertion of the levator palati. Some of the fibres of this muscle leave the palate and encircle the nasopharyngeal isthamus inside the superior constrictor muscle. It is supposed to be the detached part of the muscle palatopharyngeus (Passavent's ridge or Passavent's muscle). It is hypertrophied in cases of the cleft palate of complete type. When the soft palate during contraction comes into contact with the Passavent's ridge it closes the nasopharynx from the oropharynx. It occurs during the acts of speech and deglutition.

**Musculus Uvulae:** Musculus uvulae is a paired muscle. It arises from the posterior nasal spine and gets inserted into the mucous membrane of the uvula.

**Action:** It shortens the uvula.

**Nerve Supply:**

**Motor:** All the muscles of the palate are supplied by the cranial root of the accessory nerve except the tensor palati which is supplied by the mandibular nerve through otic ganglion.

**Sensory:** It is supplied by the greater palatine, lesser palatine, nasopalatine and the 9th nerve. Lesser palatine contains, taste fibres from the under surface of the palate.

**Blood Supply of the Palate :** It is supplied by the ascending palatine, branch of the facial artery, lesser palatine branches of the greater palatine and the ascending pharyngeal arteries.

**Note:** Actually the ascending palatine branch of the facial artery has two distinct parts. It ascends upto the levator palati muscle and it descends along the levator to reach the palate.

**Development of the Palate:** Palate develops from 3 components, i.e. Two palateal process of the maxilla and one from the primitive palate (Premaxilla). Two palate process start fusing in the midline. The process of fusion travels anteroposteriorly. Fused palatal processes meet the nasal septum which separates the two nasal cavities from each other and also from the mouth. Premaxilla has the incisors.

**Clinical:**

1. Paralysis of the palates occurs due to diphtheria. It causes impairment of the voice and the regurgitation of the fluids through the nose after swallowing.
2. Presence of accessory salivary glands in the mucosa of the hard palate may give rise to ectopic salivary tumors of the palate.
3. Cleft palate: Defective fusion of the palatal processes and the frontonasal processes causes cleft palate. It can be of four varieties:
   a. Bifid uvila
   b. Bifid soft palate
   c. Unilateral cleft palate with or without cleft lip
   d. Bilateral cleft palate with free hanging pre-maxilla.

# LARYNX

It is a box like structure situated at the cranial end of the trachea. It is the organ for production of voice and the respiration. It opens into the pharynx through the laryngeal inlet above and the tracheal below. It lies opposite the 3rd, 4th, 5th and 6th cervical vertebrae. It has an average length of about 44 mm in case of male and 36 mm in case of the female. Transverse diameter of the larynx is always greater than its anteroposterior diameter.

**Functions of Larynx: (Figure 256)**

1. *Protection:* Laryngeal inlet gets closed during swallowing. Cough reflex throws foreign material out.
2. *Phonation:* Air is inhaled, the vocal cords are adducted which is followed by exhaling air with force. The adducted vocal cords are abducted which leads to vibration. Voice is the result of vibration of the vocal cords. The quality of the voice is due to the resonance of the nose, oral cavity and the paranasal sinuses.
3. *Respiration:* Air entry is effectively controlled by the adduction and abduction of the vocal cords.
4. *Fixation of the chest:* During strenuous acts such as defaecation, mixturation and labour, larynx is closed and the chest wall gets fixed.

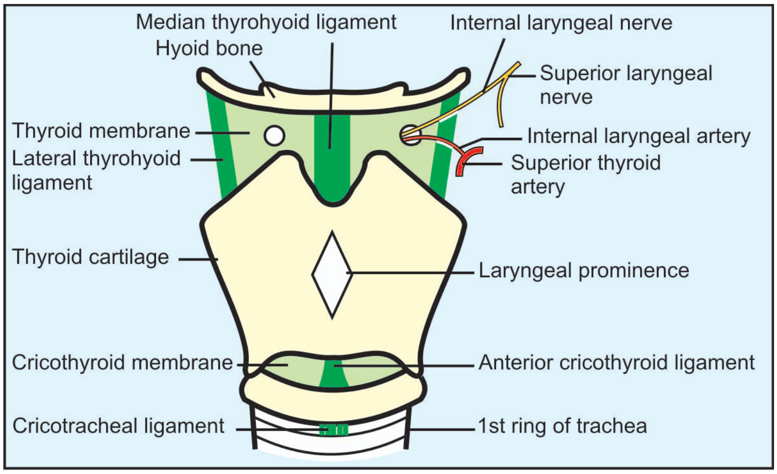



**Figure 256** Showing anterior view of articulation of thyroid and cricoid cartilages. Note the entry of internal laryngeal nerve and internal laryngeal artery entering the larynx through an opening in thyrohyoid membrane

**Structure and Composition of the Larynx:** It is composed of three paired and three unpaired cartilages, membranes connecting them, muscles and the lining mucous membrane. Unpaired cartilages are the thyroid, cricoid and the epiglottis. The paired cartilages are arytenoids, corniculate and cuneiform. The epiglottis corniculate, cuneiform and the apices of the arytenoids are fibro-elastic cartilages. Hyaline cartilages have tendency for ossification and the elastic fibrocartilages are immune from it.

**Method of Articulation:** Inferior horns of the thyroid cartilage articulate with the sides of the cricoid cartilage, through the medium of the synovial joints. Base of the arytenoid cartilage articulates with the upper border of the lamina of the cricoid cartilage, through the medium of the synovial joint, which allows rotatory and the glinding movements.

**Quadrate Ligament:** The quadrate ligament is the upper part of the fibroelastic lamina of the larynx. The cricovocal membrane is the lower part of the fibroelastic lamina of the larynx. Quadrate ligament extends from the vestibular fold below to the epiglottis above. Anteroposteriorly it extends from the arytenoids to the epiglottis.

**Cricovocal Membrane:** It is better seen after removal of lamina of the thyroid cartilage. It extends from the superior border of the cricoid to the vocal fold above. Anteroposteriorly it has an attachment to the thyroid cartilage and the arytenoid. Its upper free margin forms the vocal fold or vocal cord.

**Hyo-epiglottic Ligament (Figure 257):** It is attached to the hyoid bone and the epiglottis.

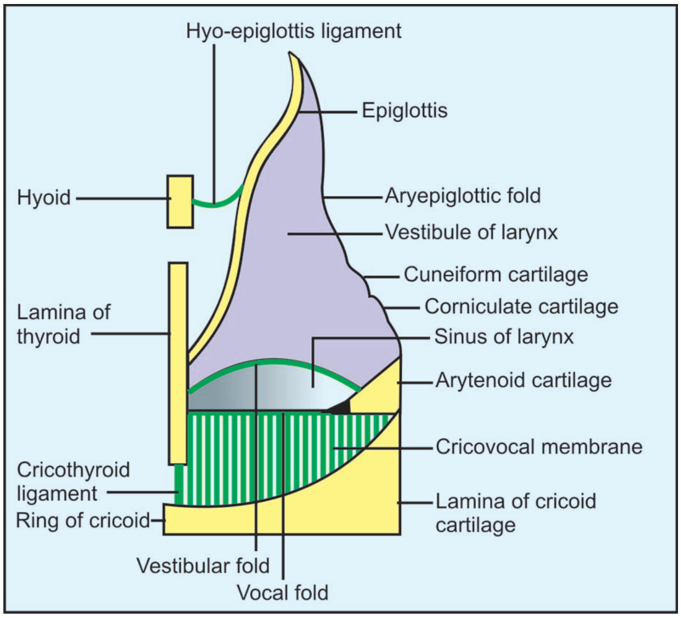



**Figure 257** Sagittal section of the larynx showing interior of the larynx and crico-vocal membrane with vestibular and vocal fold (ligaments)

## Extrinsic Ligaments

**Thyrohyoid Membrane:** Thyrohyoid membrane is the fibrous membrane between the thyroid cartilage below and the hyoid bone above. The attachment of the thyrohyoid membrane to the hyoid bone is at the superior border of the body of the hyoid. It is related to the posterior surface of the body of the hyoid and a small bursa may intervene between the two. Thyrohyoid membrane is pierced by the internal laryngeal nerve, the branch of the superior laryngeal nerve which is the branch of the vagus and the superior laryngeal artery the branch of the superior thyroid artery.

**Cricothyroid Ligament:** Cricothyroid ligament is attached to the upper border of the cricoid ring below and the thyroid cartilage above in the midline.

**Cricotracheal Ligament:** Cricotracheal ligament connects the lower border of the cricoid to the first tracheal ring.

**Intrinsic Ligaments:** Intrinsic ligaments are formed by the fibro-elastic lamina of the larynx. It is covered with the mucous membrane. The fibro-elastic lamina is interrupted by the cavity of the larynx (sinus) into two: the upper one forms the quadrate ligament and the lower one forms the cricovocal ligament. Free margin of the quadrate ligament forms the vestibular folds. Quadrate ligament extends from vestibular fold below to the epiglottis above. Anteroposteriorly it extends from the thyroid to the arytenoid.

**Cavity of the Larynx:** It extends from the inlet of the larynx to the level of the cricoid cartilage. In the middle part of the cavity there are two folds, the upper and the lower. They are paired. Upper is known as vestibular and the lower as the vocal. Vestibular folds are situated wide apart than the vocal folds. If viewed from above it is possible to see the vocal folds through the gap between the vestibular folds. The gap between the vocal folds is known as rima glottides and the gap between the vestibular folds is known as the rima vestibule.

Cavity of the larynx is divided into three parts. The uppermost part is known as the vestibule of the larynx, the middle as the sinus of the larynx, the lower as the lower part of the larynx.

**Vestibule of the Larynx:** Vestibule of the larynx lies between the inlet and the vestibular folds. It is wider above and narrow below. Its anterior wall is formed by the posterior surface of the epiglottis, side walls by the aryepiglottic folds and the posterior wall by the fold of mucous membrane between the arytenoids cartilages.

**Sinus of the Larynx (Figure 258):** Sinus of the larynx is fusiform in shape and lies between the vestibular folds above and the vocal folds below. From the anterior part of the sinus a pouch is seen ascending between the vestibular fold and the inner surface of the thyroid lamina. It may extend as high as the upper border of the thyroid cartilage. It is known as the saccule of the larynx. In the mucous membrane of the saccule are numerous mucous glands, which open into the larynx by 60 to 70 ducts. On the medial side of the saccule are the fine muscle fibres. Contraction of the muscle fibres compresses the saccule and pour the mucous secretion over the vocal folds. This helps in lubrication of the vocal cords (Saccule has rightly been described as the oil-can of the vocal cords).

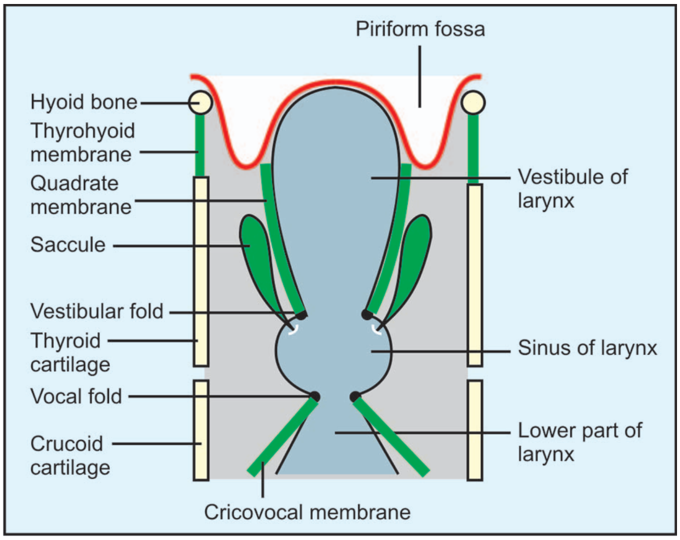



**Figure 258** Showing divisions of the larynx in a coronal section

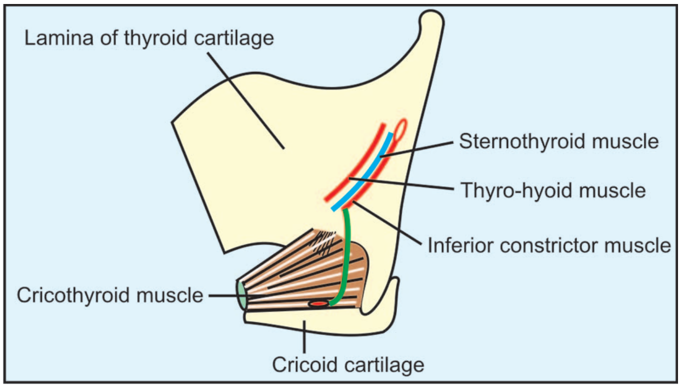



**Figure 259** Showing cricothyroid muscle

**Figure 260** Showing muscles of the larynx viewed from the back

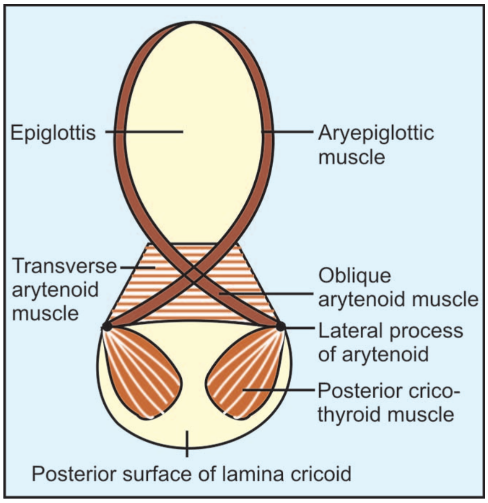
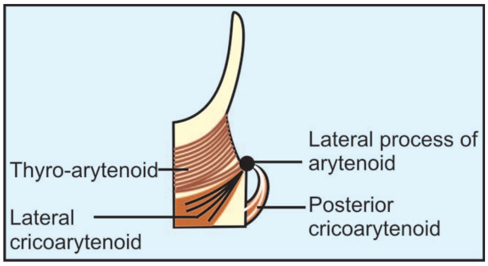



**Figure 261** Showing muscles of larynx lateral view




**Vocal Folds:** They are the whitish folds of the mucous membrane, running from the middle of the thyroid angle to the apex of the vocal process of the arytenoids. It is lined by the stratified squamous epithelium which is closely bound down to the vocal folds. As there is no submucosa, there are no blood vessels giving pearly white appearance to the vocal cords.

**Lower Part of the Larynx:** Lower part of the larynx lies between the vocal folds above and the level of the cricoid cartilage below.

## Ligaments of Larynx

**Extrinsic Ligaments:** They are as under:

1. Thyrohyoid membrane
2. Median thyrohyoid ligament
3. Lateral thyrohyoid ligaments
4. Cricothyroid ligament
5. Cricotracheal ligament

**Intrinsic Ligament:**

1. Quadrate ligament
2. Cricovocal membrane.

*Thyrohyoid membrane:* Thyrohyoid membrane fills the interval between the hyoid bone and the upper border of the thyroid cartilage. There are specialized condensations of the membrane. They are the median thyrohyoid ligament in the middle and the lateral thyrohyoid ligaments on lateral side. Median thyrohyoid ligament is attached to the upper border of the thyroid cartilage below and runs upwards to get attached to the upper border of the hyoid bone above. It passes behind the hyoid bone. There is a small bursa between the median thyrohyoid ligament and the back of the hyoid. Lateral thyrohyoid ligament is the thickening of the posterior border of the thyrohyoid membrane on either side. Thyrohyoid membrane is covered

by the thyrohyoid muscle and is pierced by the internal laryngeal nerve and the superior laryngeal vessels.

**Cricothyroid Ligament:** It lies in the mid-line. It is attached to the arch of the cricoid below and the lower border of the thyroid cartilage above. It is important to note that it is continuous with the cricovocal membrane laterally.

**Cartilages of the Larynx:**

1. *Thyroid cartilage (Figure 262):* Thyroid cartilage is unpaird and made of two quadrilateral laminae meeting anteriorly at an angle of 90 degrees in male and 120 degress in female. It is known as thyroid angle (Adam's apple). It is prominent in male after puberty. Each lamina of the thyroid has superior and the inferior cornu along the posterior border. Superior cornu is connected to the greater cornu of the hyoid through the lateral thyrohoid ligament, while the inferior cornu articulates with the cricoid. Lower down the thyroid is connected to the cricoid through the conus elasticus. Lateral surface of the thyroid lamina has an oblique line which runs obliquely downwards from above from the superior tubercle to the inferior. It gives insertion to the sternothyroid muscle, origin to the thyrohyoid muscle, the inferior constrictor of the pharynx. Superior border presents a notch which is known as the thyroid notch.

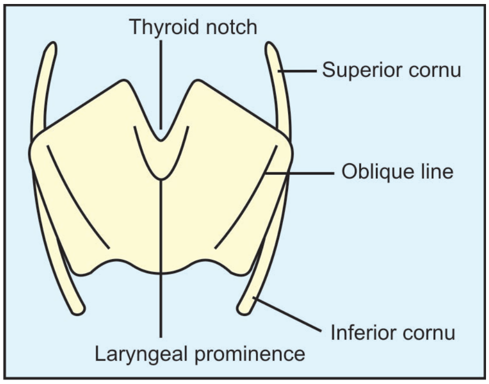



**Figure 262** Showing thyroid from the front

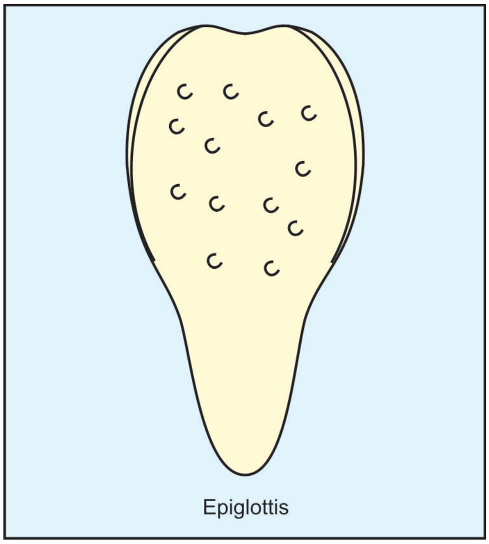
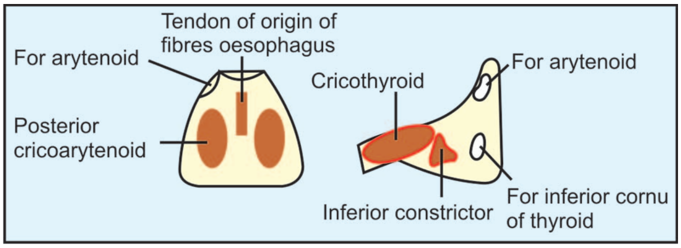



**Figure 263** Showing epiglottis

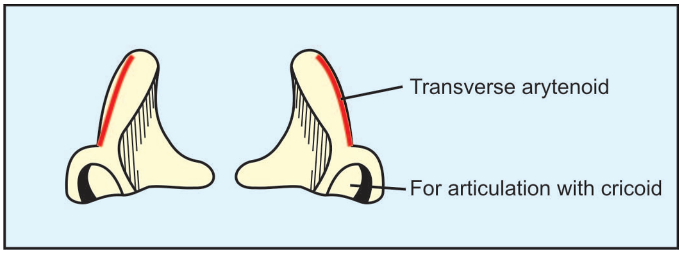
**Cricoid Cartilage (Figure 264):** Cricoid cartilage looks like a signet ring having lamina and the arch. Lamina is larger vertically measures 2 to 3 cm, while the arch is hardly 5 to 7 mm. The base of the arytenoid cartilage articulates with the lamina of the cricoid.

**Figure 264** Showing cricoid cartilage posterior and lateral views




**Arytenoid Cartilage (Figure 265):** Arytenoid cartilage is pyramid in shape. It articulates with the cricoid at the base. Its apex is directed posteromedially which articulates with the corneculate cartilage. The vocal process is directed anteriorly which gives attachment to the vocal cord. The muscular process is directed laterally and provides attachment for the posterior cricoarytenoid and the lateral cricoarytenoid muscles.

**Figure 265** Showing arytenoid cartilages




**Corniculate (Santorini) and Cuneiform (Wrisberg):** They are small nodules of elasto-fibro-cartilages situated in the aryepiglotic folds. Corniculate is conicle and is medial to the cuneiform. The cuneiform is rod like while the corniculate is triangular.

**Epiglottis (see Figure 263):** It is a leaf like lamina of elastic fibro-cartilage, attached to the thyroid angle below. It projects upwards towards the base of the tongue. It is attached to the posterior 1/3rd of the tongue by means of glosso-epiglottic folds, one median and two lateral. It is attached to the body of the hyoid by means of hyoepiglottic ligament. Posterior surface of the epiglottis is smooth and is covered by the mucous membrane having respiratory epithelium. It presents a tubercle in the middle. Small pits of mucous glands are seen over the dorsal surface of the epiglottis.

**Functions of Epiglottis:**

1. Closes the laryngeal inlet by bending over it.
2. Bolus of food rolls down from the anterior surface of the epiglottis.
3. In the fixation of the chest there is closure of the inlet of the larynx and the chest wall is fixed. The muscles of the thorax and the abdomen fully contract and as the result the chest get fixed. Fixation of the chest is essential for the acts of coughing, micturition, defecation and the labour.
4. At the laryngeal inlet foreign bodies can obstruct the respiratory passage, requiring emergency tracheostomy.

**Note:** This being a vestigeal structure its excision does not affect the swallowing, respiration or the phonation.

**Laryngeal Web:** Laryngeal web is a fold of mucous membrane between the two vocal cords does not disappear after birth. The cry of the newborn is very weak or the newborn does not cry at all.

*Note:* In infants the cartilages of the larynx are soft hence, they are easily collapsible. Infant larynx has more soft tissue therefore the oedema and the obstruction are the early complications. The level of the larynx is higher in infants, i.e. cervical four at birth and cervical 5 at the age of six, while in

the adult it comes to the level of 6th cervical vertebra. Pre-pubertal growth of the larynx is faster in the male than in female.

**Inlet of the Larynx:** Inlet of the larynx is ablong and slanting posto-inferiorly. It is bounded by the epiglottis infront, interarytenoid fold behind and the aryepiglotic folds laterally.

**Mucous Lining of the Larynx:** Mucous membrane is firmly fixed to the back of the epiglottis and the vocal cords and it is loosely attached elsewhere. Oedema of the glottis never descends below the level of the vocal cords.

**Muscles of the Larynx:**

1. Cricothyroid
2. Posterior cricoarytenoid
3. Lateral cricoarytenoid
4. Thyroarytenoid
5. Thyroepiglottic
6. Transverse arytenoids
7. Oblique arytenoid
8. Aryepiglottic
9. Vocalis.

**Note:** All the intrinsic muscle of the larynx are supplied by the recurrent laryngeal nerve except the crico-thyroid, the only intrinsic muscle of larynx situated outside and supplied by the external laryngeal nerve. Cricothyroid the only tensor of the vocal cords.

1. *Cricothyroid (See Figure 259):* Cricothyroid arises from the ring of the cricoid and gets inserted into the lower border of the lamina of thyroid and the inferior cornu. It is supplied by external laryngeal nerve and is the only intrinsic muscle of the larynx supplied by the external laryngeal nerve and the only tensor of the vocal cords.
   *Mechanism of action:* The ring of the cricoid is pulled cranially by the cricothyroid muscle as a result amino cricoid with the arytenoids automatically go dorsally. This increases the distance between the thyroid angle and the vocal process of the arytenoid make the vocal cord tense.
2. *Posterior cricoarytenoid: (see Figure 260)* Posterior cricoarytenoid is the only powerful abductor muscle of the vocal cords and probably the only important muscle in the body. It arises from the posterior surface of lamina of the cricoid. Fibres to upwards laterally and get inserted in the muscular process of the arytenoid.
3. *Transverse arytenoids:* It runs between the posterior surfaces of the artenoid cartilages across the midline. It is the only unpaired muscle of the larynx.
4. *Oblique arytenoids (See Figure 260):* They are on the posterior surface of the transverse arytenoid and are arranged like a letter "X", where they cross. Each of them arises from the muscular process of the arytenoids of one side, and passes obliquely to the apex of the arytenoids of other side. Most of the fibres are continue in the aryepiglottic fold and get inserted into side of epiglottis. It helps in closing the laryngeal inlet.
5. *Lateral cricoarytenoid muscle:* Lateral cricoarytenoid muscle arises from the upper border of the side of the cricoid arch. Fibres run upwards and backwards for its insertion into the muscular process of arytenoid. They are the adductors of the vocal cords and help in reducing the width of the rima glottidis.
6. *Thyroarytenoid: (see Figure 261)* Thyroarytenoid arises from the deep surface of the thyroid nearer its anterior border and runs posteriorly to

the anterolateral surface of the arytenoid cartilage. It pulls the arytenoids forward and thus relaxes the vocal cords. Some of the fibres of this muscle get inserted into the margin of the epiglottis. This part is known as thyroepiglottic muscle. Fibres associated with the vocal cord is known as the vocalis.

**Nerve Supply:** It is divided into two, i.e. the motor and the sensory.

1. *Motor:* Recurrent laryngeal nerve and external laryngeal, nerves are the motor nerves of the larynx.
2. *Sensory:* Internal laryngeal the branch of superior laryngeal nerve supplies the mucous membrane of the larynx above the vocal cords.
3. Recurrent laryngeal nerve supplies the mucous membrane of the larynx below the vocal cords. Damage to the internal laryngeal nerve leads to the loss of cough reflex making it easy for the foreign bodies to enter the respiratory tree.

**Blood Supply:** Larynx is supplied by the superior laryngeal artery the branch of superior thyroid artery and the inferior laryngeal artery the branch of the inferior thyroid artery.

**Venous Drainage:** To the thyroid veins:

**Lymphatic Drainage:** Above the vocal cord to the superior group of deep cervical nodes and below the vocal cords to the inferior group of deep cervical nodes.

**Clinical:**

1. Inflammation of the larynx is known as laryngitis. Chronic laryngitis is due to over use or misuse of the voice. Atmospheric pollution has added to the list of predisposing factors.
2. Recurrent laryngeal has an intimate relation with the interionthyroid artery near the gland. Hence, the ligation of the inferior thyroid artery should be done away from the gland. On the other hand the external laryngeal nerve is close to superior thyroid artery away from the gland hence the superior thyroid artery should be ligated near the gland.
3. Laryngotomy is done through the anterior wall of the lower division of the larynx.
4. Injury to the superior laryngeal nerve results in weakness of phonation as a result of damage to the external laryngeal nerve which supplies the cricothyroid muscle. The internal laryngeal nerve the branch of the superior laryngeal nerve supplies the mucous membrane of larynx upto vocal cords. In bilateral injury of the superior laryngeal nerve the cough reflex is totally lost.
5. Complete sectioning of recurrent laryngeal nerve on one side makes the cord lie in the position between abduction and adduction. It does not cause major loss of function except the change in the voice as the vocal cord of the other side tries to compensate. There is no airway obstruction or aspiration.

   Bilateral partial damage to both the recurrent laryngeal nerves bring the cords closure causing severe stridor requiring trachiostomy.

   *Note :* Loss of voice indicates the involvement of recurrent laryngeal nerves in carcinoma of thyroid or malignant cervical lymph nodes.
6. The opening of the larynx being small foreign bodies can obstruct the airway. Oedema of the larynx leads to airway obstruction.
7. *Functional aphonia:* It is seen in young female. There is a sudden loss of voice with normal vocal cords. In this condition the adductors are affected first.
8. *Singer's node* Singer's node is seen in bad singers and the mothers who shout at their children. The basic pathology is the hyperkeratosis of the vocal cord.

9. *Laryngocoel:* The air filled sacculae of the laryngs projects into the neck. It is commonly seen in trumpet players and glass blowers.

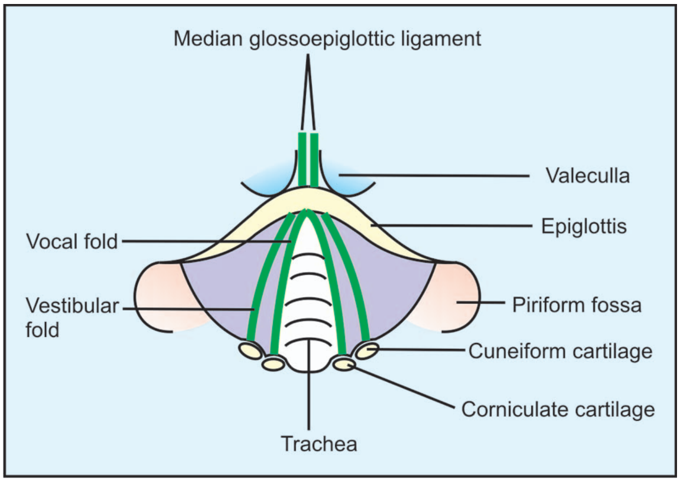
   Carcinoma of the vocal cord has better prognosis due to relative absence of blood supply and the lymphatics in the cord.
10. *Semen's law:* In partial damage of the recurrent laryngeal nerve, abductors of the larynx get paralysed first and are last to recover.

**Laryngoscopy :** Indirect laryngoscopy is done by means of the laryngeal mirror and the direct one is done with the laryngoscope.

*Structures viewed in laryngoscopy (Figure 266):*

a. Base of the tongue.
b. Epiglottis
c. Glossoepiglottic folds.
d. Pyriform fossa
e. Reddish vestibular cords placed wide apart.
f. Pearly white true vocal cords can be seen through the gap between the vestibular folds. (Rima vestibuli). Recently microscopic and fiberoptic laryngoscopes are in use.

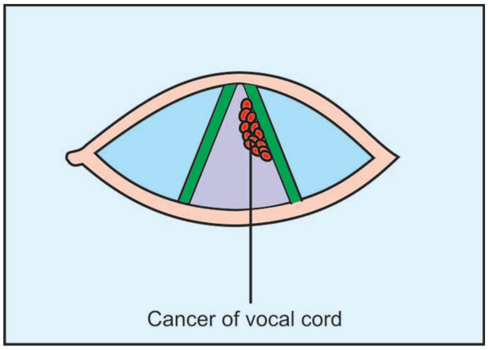
**Figure 266** Showing laryngoscopic view of cavity of larynx




Left recurrent laryngeal nerve can get involved in the thorax due to the carcinoma of the bronchus or carcinoma of the oesophagus. It can be stretched in aortic anuerysm. It is compressed against the aortic arch due to higher displacement of the left pulmonary artery.

**Carcinoma of Vocal Cords (Figures 267 to 270):** Carcinoma of vocal cords occurs mostly in the anterior part of the cords. Due to absence of the submucosa vocal cords look pearly white. Vocal cords are the dividing line between the lymphatics of the upper and the lower parts of the larynx. However, the lymphatic freely communicate posteriorly allowing the cancer of the larynx to have free hand in the spread of the disease. Relative avascularily and poor lymphatics make carcinoma of the anterior part of the vocal cords spreads slowly and has better prognosis.

**Figure 267** Showing cancer of vocal cord



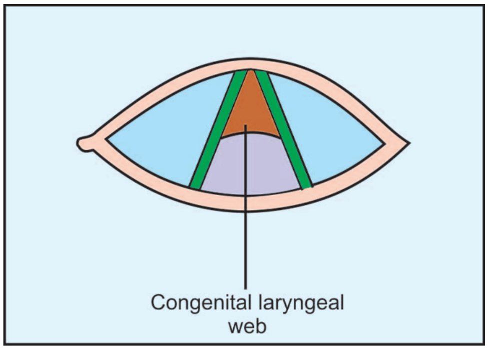



**Figure 268** Showing congenital laryngeal web

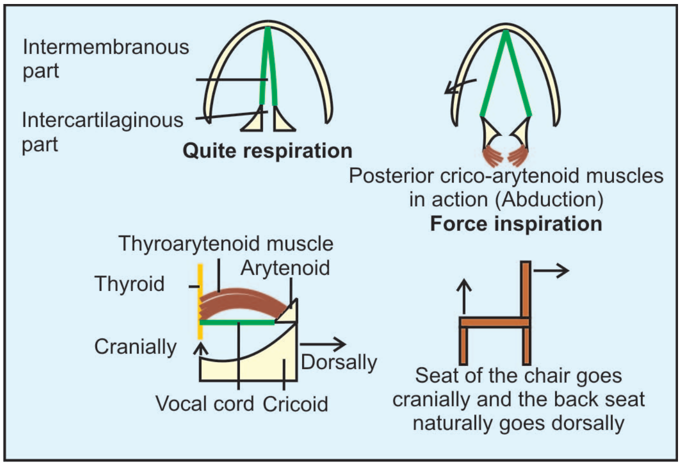



**Figure 269** Cricothyroid pulls the ring of cricoid which carries the lamina of cricoid and arytenoid dorsally making the cord tense

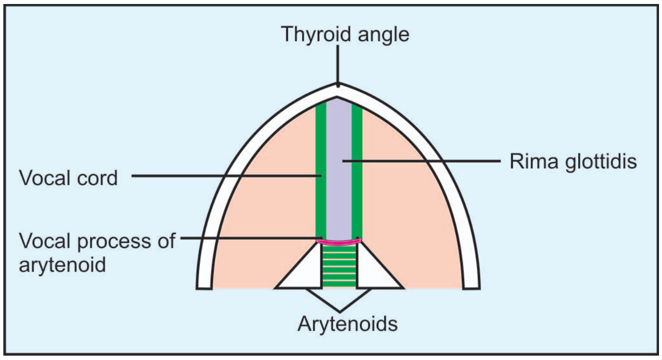



**Figure 270** Showing rima glottides

# EXTERNAL NOSE

External nose is pyramidal in shape and projects from the lower part from the forehead downwards and forwards between the eyes. It has the root the dorsum and the tip. Tip of the nose is firm to feel and is supplied by the external nasal nerve which is the continuation of the anterior ethmoidal nerve.

*Bony framework of the nose is formed by the:*

1. Nasal bones
2. Frontal process of the maxilla and
3. The nasal process of the frontal bone.

**Cartilaginous Frame Work (Figures 271 and 272):** It is formed by the:

1. Lateral nasal cartilage
2. Major alar cartilage.
3. Minor alar cartilages and the fibro-fatty tissue.

In brief the nose has a bony framework above and cartilaginous below. Exteternal naris is formed by the major alar cartilages and the fibro-fatty tissues which forms the lower mobile part of the septum. Major alar cartilages forms the alae and send the septal process towards the septal cartilage. External naris have been compared with a valve controlling the intaking and the outgoing air. Lower part of the septum which is made up of fibro-fatty tissues is known as columella. Skin of the external nose is thin and is loosely attached to the underlying structures except at the tip and the alae. Here, the skin contains large amount of sebaceous glands and hair which are known as the vibraese. The vibraese are arranged in a way which make them act like the filter of the nose. Interior of the external naris is known as the vestibule.

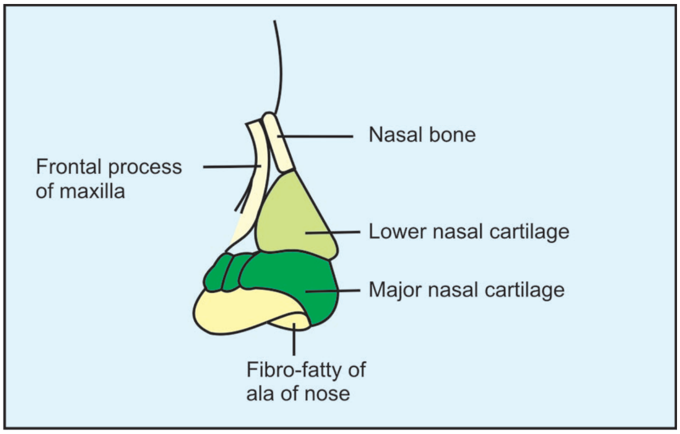



**Figure 271** Showing structures of forming the external nose

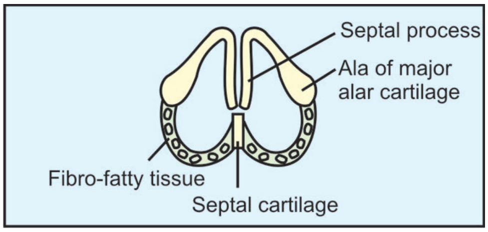


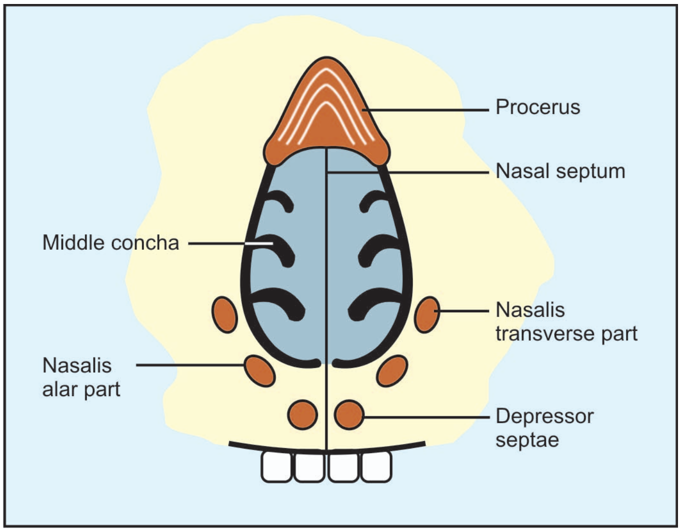

**Figure 272** Showing formation of external naris viewed from below

*Musculature of the nose:*

1. Procerus
2. Nasalis – Horizontal and alar part.
3. Levator labi superior alaeque nasi.
4. Depressor septae

1. *Procerus:* Procerus is pyramidal in shape and covers the dorsum and the bridge of the nose. It arises from the lower part of the nasal bones and gets inserted into the skin between the eyebrows. It is partly fused with the medial side of the frontalis muscle.
   *Action of the procerus:*
   1. Lowers the medial side of the eyebrow:
   2. It produces wrinkles over the bridge of the nose.
   3. It is the muscle of frowning and concentration.
   4. Helps in reduction of the glare of bright light (sunlight).
2. *Nasalis (Figure 273):* Nasalis has two parts—transverse and the alar. The transverse part is also known as the compressor naris. It arises from the maxilla near the nasal notch, goes dorsomedially to meet the fellow of the opposite side and the procerus. Dilator naris arises from the maxilla, inferomedial to the compressor naris and goes to the alar cartilage.

**Figure 273** Showing anterior nares with some muscles of the external nose




**Depressor Septae (Figure 274):**
**Action:**

It arises from the maxilla above the incisors and gets attached to the mobile part of the nasal septum. It assists in the alar part of the nasalis in widening of nasal aperture. Compressor naris compresses the nasal opening above the vestibule and the dilator naris pulls the ala laterally leading to the widening of the nasal aperture.

*Action of the nasal muscles:*

1. Deep inspiration
2. During exertion
3. During emotions.

*Blood supply of the external nose* is supplied three arteries:

1. Facial
2. Ophthalmic
3. Maxillary.

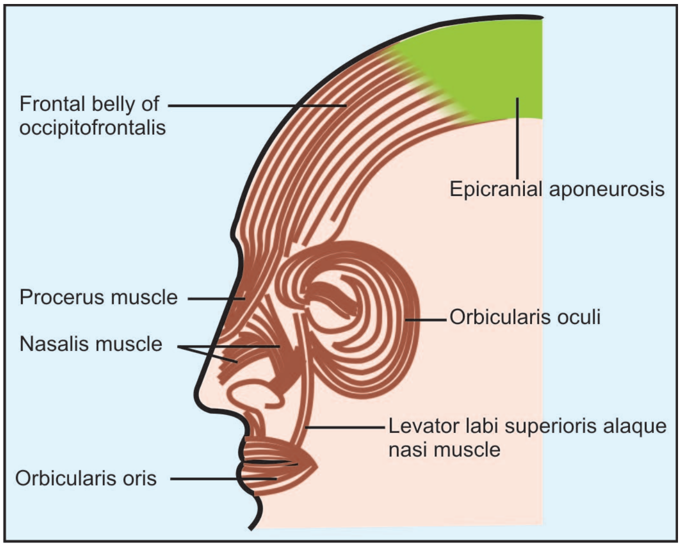



**Figure 274** Showing muscles of face including epicranial aponeurosis

Facial artery gives alar and lateral nasal branches to the nose. Septal branch of the facial supplies the antero-inferior part of the septum. Dorsal nasal branch of the ophthalmic and the infraorbital branch of the maxillary arteries supply the nose.

**Nerve Supply:** Nasal muscles are supplied by the facial nerve.

**Sensory Supply of Nose:** Nose is supplied by the infratrochlear, external nasal and infra-orbital nerves.

**Lymphatic Drainage of Nose:** It drains into the preauricular and the submandibular nodes.

**Development of Nose:** Fronto-nasal process appears between the developing fore-brain and the stomodium. Fronto-nasal process divides into two the median nasal process and the lateral nasal processes. Posteriorly the nasal cavity presents the bucco-nasal membrane. Posterior nasal apertures are formed after the rupture of the bucco-nasal membrane. Non-rupture of the bucco-nasal membrane leads to the nasal atresia. Olfactory placodes of the fronto-nasal processes get depressed and form the nasal cavity. The depressed olfactory placodes look like pits hence known as the olfactory pits.

Primitive nasal septum which forms the median partition of the nasal cavity forms the nasal septum (definitive nasal septum).

**Paranasal sinuses:** They develop as the evaginations of the nasal mucosa in the area around the nasal cavity. As a result all the paranasal sinusus communicate with the nasal cavity. Maxillary air sinus develops in the 4th month of intra-uterine life and is present at birth along with the small anterior ethmoidal sinuses. The maxillary air sinus is fully developed only after the eruption of the second molar. Capacity of the maxillary air sinus is between 15 to 25 ml.

*Congenital and other deformities of the nose:*

1. Bifid nose with cleft palate.
2. Deformed nose
3. Deviated nasal septum (DNS)
4. Humped nose
5. Crucked nose: In this the dorsum of the nose looks like the letter ‘C’ or the letter ‘S’.

6. Potato nose: is seen in rhinophyma. Due to fibrosis and hyperplasia the tip and the alae of the nose.
7. *Woody nose:* External nose is firm and woody. It is seen in rhinoscleroma which is a chronic granulomatus infection presenting as sclerosis and the stenosis of the nasal passage.

**Historical:** Cutting of the nose was the punishment given to the condemned prisoners of war or enemies. Sushruta the great Indian surgeon did the reconstruction of the nose (Rhinoplasty) first time in the history and is recognized the father of plastic surgery.

# NASAL CAVITY

Nasal septum divides the cavity into two right and the left halves. Each half of the nasal cavity is 5-7 cm long and 5 cm in height. Transverse diameter at the floor is about 1.25 cm while the roof is about one to two millimeters. Each nasal cavity has the lateral wall presenting 3 conchae, and 3 meatuses namely the superior, middle and inferior from above downwards. Medial wall is formed by the central partition, e.g. the nasal septum. Nasal cavity has the roof, the floor, the lateral medial wall and the anterior and posterior nasal apertures.

**Roof (Figure 275):** The roof presents slope anteriorly and posteriorly, while the middle part which is formed by the cribriform plate is horizontal. Anterior part of the roof is formed by nasal process of frontal bone, the nasal bones and the cartilages. The posterior part is formed by the antero-inferior part of the sphenoid, parts of vomer, palatine and the medial pterygoid plates.

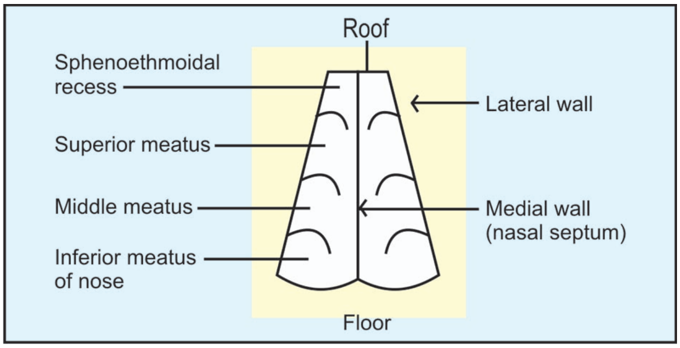



**Figure 275** Coronal section of nasal cavity showing walls of the cavity and conchae meatuses

**Floor:** Floor is about 5 cm in length and 1.5 cm in width. It is concave from side to side.

**Lateral Wall (Figure 276):** The lateral wall presents three conchae and three meatuses. Under each concha lies the meatus. Ethmoidal air sinuses lie between the lateral wall of the nose and the orbital cavity, while the maxilliary air sinus is placed lateral to the nasal cavity. For convenience of description the lateral wall of the nose is described as having three separate areas. They are the vestibule, the atrium of the middle meatus and the region of the conchae and meatuses.

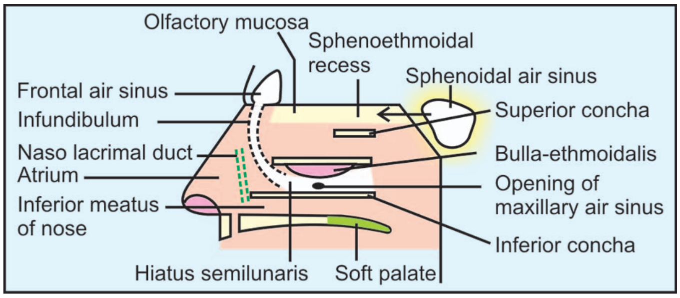



**Figure 276** Showing the lateral wall of nose. Please note that the maxillary air sinus receives secretion from frontal air sinus through infundibulum

**Vestibule of the Nose:** Vestibule of the nose lies above the nostrils and is lined with skin and presents special arrangement of the hair. Anterior hair incline backwards and the posterior forwards (vibrssae) and act as filters. It has sebaceous and sweat glands.

**Atrium of the Middle Meatus:** It lies immediately in front of the middle meatus of the nose. Near the nasal bone, its lateral wall presents an elevation which is seen running

downwards and forwards. It is known as agger nasi. It is well developed in some mammals and forms an additional concha.

**Areas of Meatuses and Conchae:** Superior and middle conchae are parts of the ethmoid bone and the inferior concha is the separate bone. They are curved plates attached to the lateral wall of the nasal cavity.

**Superior Concha:** Superior concha is the shortest of the conchae, presents on the postero-superior part of the lateral wall. It begins little below the middle of the cribriform plate, runs downwards and backwards and ends below the body of the sphenoid.

**Middle Concha:** It extends from the atrium anterior to the posterior nasal aperture posteriorly.

**Inferior Nasal Concha:** Inferior nasal concha is the largest of the three and practically occupies whole of the lateral wall of the nose.

**Superior Meatus:** Superior meatus is the narrow fissure between the superior and the middle conchae. Posterior group of ethmoidal sinuses open into it.

**Middle Meatus:** Middle meatus is well seen after the middle concha is pulled upwards. Upper and anterior part presents an infundibulum, which connects the frontal air sinus with nasal cavity. Infundibulum is seen opening into the hiatus semilunaris. In the hiatus semilunaris the maxillary air sinus opens. Upper boundary of the hiatus semilunaris is formed by a bulging known as the bulla ethmoidalis formed by the bulge the middle ethmoidal sinuses. Situated on the bulla there are apertures of the ethmoidal air sinuses. It has already been stated that the opening of the maxillary air sinus is situated above the level of the floor of the maxillary sinus. Secretions from the frontal air sinus reach the middle meatus and pass into the maxillary air sinus. (Maxillary sinus is described as secondary reservoir of the frontal air sinus). Above the superior concha there is the space known as the spheno-ethmoidal recess, into which the sphenoidal air sinus opens. In the inferior meatus of the nose the nasolacrimal duct opens anteriorly. The opening is provided with a valve known as valve of Hister.

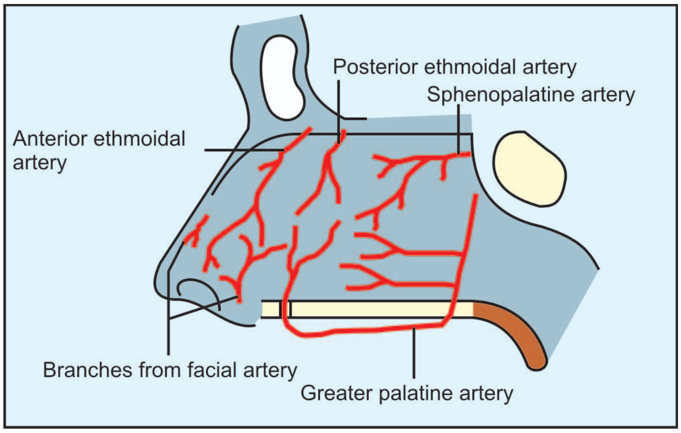
**Mucoperiosteum:** Mucous membrane of the lateral wall of the nasal cavity is fixed to the bone and is known as a mucoperiosteum. The superior part of the mucous membrane is related to the superior concha is of an olfactory and rest of mucous membrane is the respiratory. Mucous membrane is very thick and spongy specially over the lower border and the posterior ends of middle and the inferior nasal conchae. Specially in the region of inferior nasal concha the mucous membrane is very thick. This character of the mucous membrane helps in blocking the nasal cavity, i.e. vascular congestion. Mucoperiosteum of the nasal cavity is continuous the naso-lacrimal duct and with the conjunctiva. It is continuous with the pharyngeal mucous membrane through the posterior apertures. In addition to this the mucous membrane has continuity with the mucous membrane of the paranasal sinuses. The greater vascularity and the extensive mucous surface helps in moistening and the warming air which is inhaled.

*Blood supply of lateral wall (Figure 277):*

Lateral wall is supplied by the following arteries:

1. Anterior ethmoidal
2. Posterior ethmoidal
3. Sphenopalatine
4. Facial
5. Greater palatine.

Figure 277 Showing blood supply of lateral wall of nose



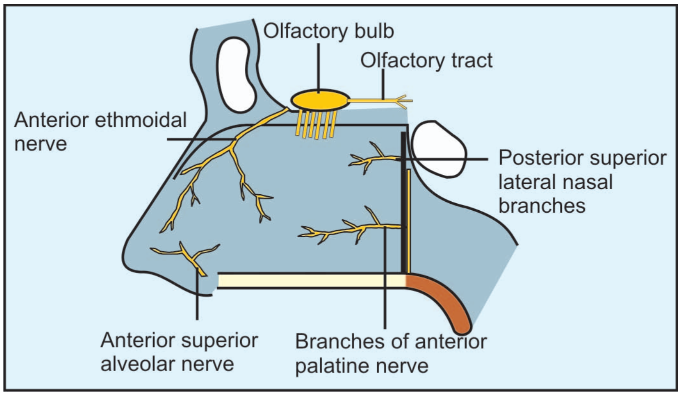

**Nerve Supply (Figure 278):**

*Nerves of common sensation:*

1. Anterior ethmoidal
2. Posterior, superior, lateral nasal
3. Anterior superior alveolar.

Nerve of special sensations is olfactory.

Figure 278 Showing nerves supply of lateral wall of nose




**Clinical:** Nasal polyps appear in the nasal cavity causing nasal obstruction and discharge. Nasoscopy is done to look for nasal pathology from inside.

# NASAL SEPTUM

It divides the nasal cavity into two equal halves, however, it is rarely placed accurately in the median plane, usually being shifted to the right. Each half of the nasal cavity has the roof, floor medial and lateral walls. Nasal septum has four borders, e.g. superior, inferior, anterior and the posterior. It forms the medial wall of both the nasal cavities (Figure 279).

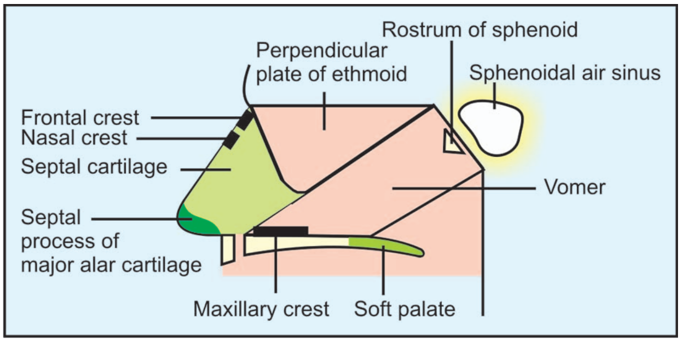



**Figure 279** Showing formation of nasal septum

### Construction of the Nasal Septum (Figure 280):

It is formed by the following:
1. Vomer below and behind,
2. Perpendicular plate of the ethmoid above and behind,
3. The septal cartilage below and infront.
4. Septal process of the inferior nasal cartilage.
5. Nasal crest
6. Maxillary and palatine crest
7. Anterior nasal spine and the sphenoidal rostrum
8. Lower mobile part is known as columella. It is made up of fibro-fatty tissue.

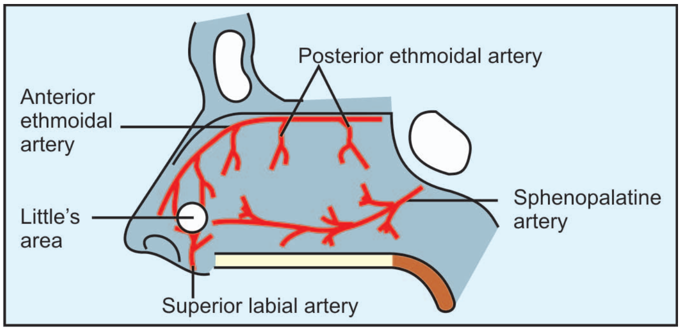



**Figure 280** Showing blood supply of nasal septum

### Septal Cartilage (Figure 281):

Septal cartilage occupies the gap between the vomer and the perpendicular plate of the ethmoid, and extends forwards towards the tip of the nose. Its upper and posterior borders are in opposition with the anterior border of the perpendicular plate of ethmoid and the lower fits into the groove of the anterior border of the vomer and the nasal crest of the maxilla, while its upper and anterior border is in contact with the sutures between the two nasal bones. Below it is related to the lateral nasal cartilages. Lower and anterior border is free and extends anteriorly as far as the anterior nasal spine.

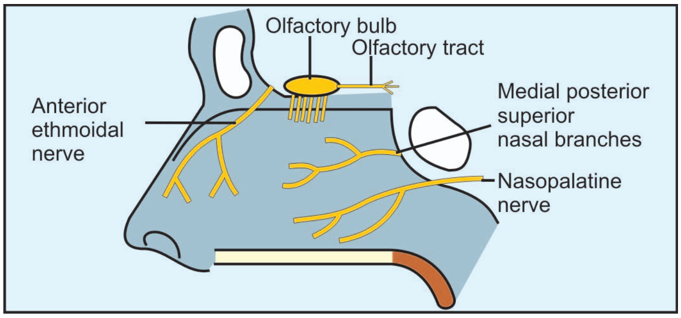



**Figure 281** Showing nerves of nasal septum

**Vomer:** Vomer has two alae which fit in the sphenoidal rostrum above immediately below the body of the sphenoid. It has grooves for the long sphenopalatine nerves on either side.

**Mucous Membrane:** Mucous membrane is firmly fixed the periosteum and the perichondrium, similar to the mucous membrane of the lateral wall of the nose, it is divisible into olfactory and the respiratory areas, of which olfactory area is less than upper third of the septum. Respiratory area is very thick, vascular and contains numerous mucous glands. Only serous type of the glands are present in the olfactory.

**Blood Supply:** It is supplied by the:

1. Anterior ethmoidal
2. Posterior ethmoidal and
3. Superior labial arteries (Branch of facial).

**Clinical:** At the antero-inferior area or the part of the nasal septum is an arterial plexus known as KIESSELBACH's plexus. It is formed by LES—L – Labial, E – Ethmoidal, S – Sphenopalatine.

Interestingly this area is known as Littles area. One may say the arteries taking part in the formation of the plexus at the Littles area as "LES" (Little less).

Little's area is the site of bleeding in epistaxis. Normally the bleeding from the nose, i.e. epistaxis can be stopped by pinching of the nose and anterior and the posterior nasal packings. If bleeding refuses to stop the anterior ethmoidal artery is ligated in the orbit or the maxillary is ligated through the transmaxillary approach. At times it may need the ligation of the external carotid artery.

**Septal Deviation:** Deviation of the nasal septum from the median plane is usually due to the bulging of the vomer and the perpendicular plate of the ethmoid along their line of union due to unequal growth. Deviation of nasal septum does not occur before the age of 7 years as perpendicular plate of ethmoid and vomer do not join before 7 years.

**Clinical:**

1. DNS – Deviation of nasal septum
2. Septal haematoma
3. Septal abscess
4. Perforation of the nasal septum
5. Epistaxis

Normally minor degree of the nasal septum does not require surgical treatment, however in extreme degree of deviation the operation of sub-mucosal resection is done and the bony spur is removed. The nasal septum is approached by raising the mucous membrane on either sides of the septum.

**Septal Haematoma:** The collection of blood occurs between the nasal septum and the mucous membrane of either side. It may be due to trauma or postoperative after submucosal recesection of the septum (SMR).

**Cellulitis and Furunculosis of the Nose:** As the vestibule of the nose is lined by the skin having sebaceous glands, furunculosis of the nose is not uncommon and it may lead to nasal cellulitis.

**Shapes of the Nose:** Normally the nose is pyramidal in shape. However, it can be depressed, humped and crooked. The crooked nose is 'S' shaped.

1. *Adenoid facies* Due to the enlargement of the adenoids, the child develops the habit of oral breathing through the mouth instead of the nasal. Nose appears pinched due to atrophy of the nasal muscles.
2. *Fracture of nasal bones :* It is usually due to trauma and can be palpated before the oedema develops.
3. *Anterior and posterior rhinoscopy:* Structures seen in the anterior rhinoscopy are the three chonchae. Nose in the child can be examined by lifting the tip of the nose as there are no vibriaese.

   Structures seen through the posterior rhinoscopy :

1. Middle and inferior conchae,
2. Nasal septum,
3. Soft palate,
4. Uvula,
5. Openings of the pharyngo-tymphanic tubes and
6. Fossae of Rosenmullar.

# PTERYGOPALATINE GANGLION

Pterygopalatine ganglion is situated in the upper part of the pterygo-palatine fossa, opposite the sphenopalatine foramen. It is suspended from the maxillary nerve by two roots.

**Roots:**

1. Sensory – is from the maxillary nerve.
2. Sympathetic is from the nerve of the pterygoid canal.
3. Parasympathetic fibres (secretory) are for the lacrimal gland.

Nerve of the pterygoid canal is formed by the union of the greater superficial petrosal and the deep petrosal nerves. The deep petrosal nerve is formed by the sympathetic plexus of the internal carotid artery. The fibres brought by the greater superficial petrosal nerve are relayed in the ganglion. These are the secretory (parasympathetic) fibres for the lacrimal gland.

**Branches (Figure 282):** They are orbital, short and long sphenopalatine, greater palatine and the pharyngeal.

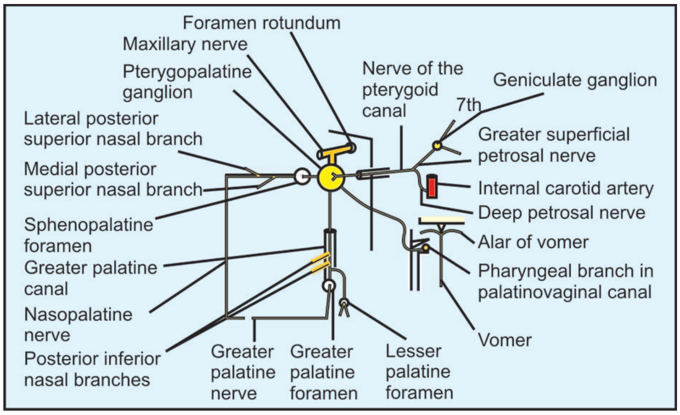



**Figure 282** Showing pterygopalatine ganglion and its connectios

**Orbital Branches:** Pass through the inferior orbital fissure and supply the lacrimal gland and the periosteum of the orbit.

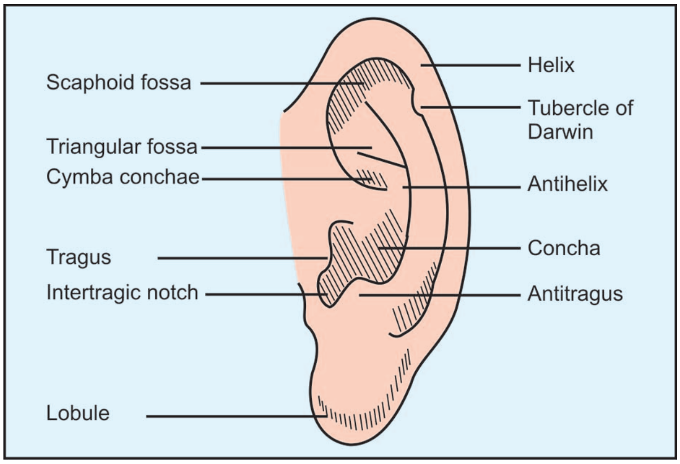
**Sphenopalatine Nerve:** Pass it through the sphenopalatine foramen and supply the mucous membrane of the nose through the lateral and medial posterior superior nasal nerves.

**Pharyngeal Branch:** It passes backwards through the palatinovaginal canal and supplies the pharyngeal mucous membrane and the mucous membranes of the sphenoidal air sinus.

# EXTERNAL EAR

**Auricle (Figure 283):** Auricle is also known as the pinna. Major portion of it is made up of the single plate of elastic cartilage presenting elevations and depressions. It is covered with skin on the outer and inner surfaces. Lowest part of the auricle is soft to touch. It consists of connecting tissue covered with skin and is known as the lobule of the ear. The auricle presents an outer rim known as the helix. Inside the helix lies another curved ridge, starting from the antitregus. It is known as antihelix. It curves upwards and divides into two limbs to enclose the depression known as the triangular fossa. Under the helix lies scaphoid fossa. Postero-superior margin of the helix presents the tubercle known as the Darwin's tubercle. In front of the antitragus there is intertragic notch followed by an elevation known as the tragus.

**Figure 283** Showing external ear




The area bounded by antitragus is divided into two:

1. Cymba conchae above and
2. The concha below.

Cymba conchae corresponds to the surface area of the suprameatal triangle. Concha continues as the external auditory canal which leads to the tympanic membrane.

**Muscles of the Auricle:** They are: (1) Extrinsic and (2) The intrinsic. These muscles are not well developed in the human beings. Intrinsic muscles are capable of changing the shape of the auricle while the extrinsic muscles move the auricle. Extrinisic muscles are in three groups, i.e. superior, anterior and the posterior. They are supplied by the facial nerve.

**Blood of the Auricle:** Anteriorly it is supplied by the superficial temporal artery and posteriorly by the posterior auricular.

**Lymphatic Drainage:** Lymphatics of the auricle drain into the pre-auricular, post-auricular and the superficial cervical lymph nodes.

**Nerve Supply (Figure 284):** Upper 2/3rd of the lateral surface of the auricle is supplied by the auriculo-temporal nerve while the lower 1/3rd by the great auricular nerve. Medial surface of its 2/3rd surface is supplied by the lesser occipital nerve, and the lower 1/3rd by the great auricular nerve. Root of the auricle is supplied by the auricular branch of vagus (Nerve of Arnold).

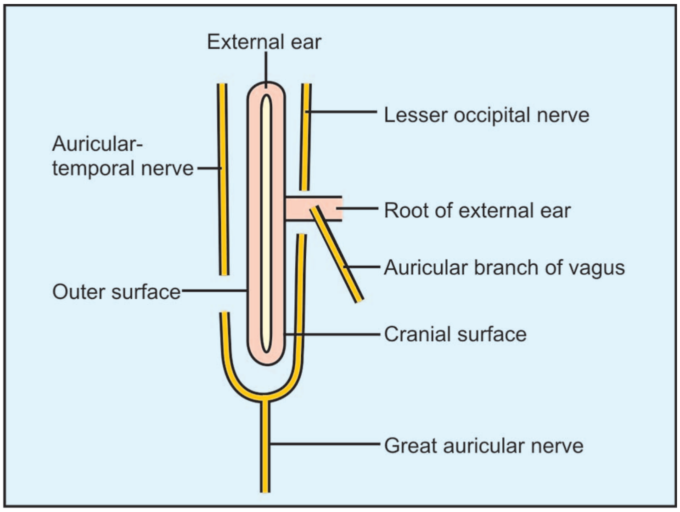
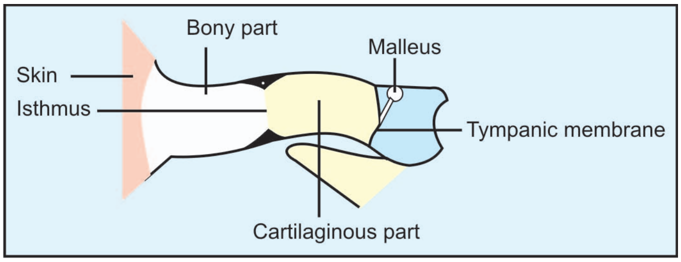



**Figure 284** Showing nerve supply of external ear coronal section of the external ear (Schematic)

**External Auditory Canal (Figure 285):** External auditory canal runs from the concha to the tympanic membrane. Its direction is complicated, however, it is mainly directed medially with tendency to go forwards, upwards and downwards. The "S" shaped course of the canal prevents the examiner from having a look at the tympanic membrane. The curve can be obliterated by pulling the auricle laterally upwards and backwards. The length of the canal is 24 mm. Its medial 2/3rd is bony and the lateral 1/3rd is cartilaginous. Bony canal measures 16 mm while the cartilaginous canal measures only 8 mm. The cartilaginous part is wider than the bony part. As the tympanic membrane is set obliquely at an angle of 55 degrees to the floor of the canal. Bony part of the canal is formed by the "C" shaped tympanic plate and postero-superior deficient part is formed by the squamous part of the temporal bone. Skin of the meatus is thin in the bony part and is firmly attached to the periosteum. The cartilaginous incomplete ring of the tube is formed by the "C" shaped cartilaginous plate, while the deficient part of the ring is completed by the fibrous tissue. Skin of the cartilaginous part is attached to the periochondrium and is thicker than the skin of the bony part. It contains sebaceous and ceruminous glands (modified sweat glands) and hair. Ceruminous glands produce wax like material which prevents maceration of the tissue in the presence of water. Due to the firm fixity of the skin to the underlying cartilage inflammations of the cartilaginous portion are very painful. It is known site for the furuncle (Furuncle is the staphylococcal infection of the hair follicles). The bony meatus presents the narrow part known as isthmus which is situated 6 mm lateral to the tympanic membrane. Foreign bodies get lodged medial to the isthmus and get impacted which makes it difficult to remove. There is a small recess situated medial to the isthamus known as anterior recess. It acts as a cesspool for discharge of debris in cases of infections of the ear. Antero-inferior part of the bony meatus has the deficiency known as the foramena Huschke. It remains patent up to the age of 4 years, and is closed in adults. It acts as the gate for the infections of the parotid to enter the canal.

**Figure 285** Showing external auditory canal




The cartilage of the meatus is continuous with the cartilage of the external ear. It has two fissures known as fissures of Santorini. They act as the gate of entry for the infections from the parotid and the superficial mastoid regions.

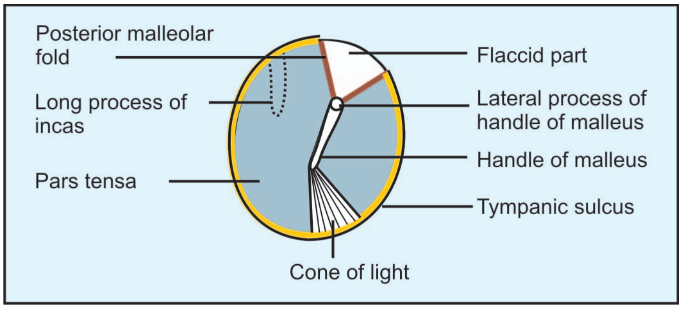
**Lymphatic Drainage:** Lymphatics from the canal goes to pre-auricular, post-auricular and the superficial cervical nodes.

**Blood Supply:** Superficial temporal and the posterior auricular arteries supply the outer part of the canal while the inner part of the canal is supplied by the deep auricular branch of the maxillary artery.

**Nerve Supply:** Auriculo-temporal nerve supplies the skin of the anterior half of the canal and the posterior half is supplied by the auricular branch of the vagus.

**Tympanic Membrane: (Figure 286)** Tympanic is the fibrous membrane oval in shape covered with skin from outside and the mucous membrane from the inside. The middle core of the membrane is made up of fibrous tissue. Embryologically the tympanic membrane exhibits the combination of ectoderm, mesoderm and the endoderm. It lies between the auditory canal and the middle ear. Narrowest part of the canal lies 5 mm away from the tympanic membrane. It is known as the isthamus of the canal. Tympanic membrane measures 10 mm verticle and 8 mm transverse and is obliquely placed at an angle of 55 degrees with the floor of the canal. Its outer surface is directed laterally forwards and downwards. In the newborn the tympanic membrane faces downwards. Outer surface of the tympanic membrane is concave while its medial surface is convex at the centre. The tip of the handle of the malleus is attached to the apex of the convex part. It is known as the umbo. Outer thickened part of the tympanic membrane is fixed to the tympanic sulcus of the temporal bone. The sulcus is incomplete above where the tympanic membrane is attached to the tympanic notch. Thickened part of the tympanic membrane situated peripherally runs towards the lateral process of the malleus. These are known as the anterior and the posterior malleolar folds. The part between the malleolar folds is lax and is known as pars flaccida while the rest of the tympanic membrane which is tense being fitted in the tympanic ring is known as the pars tensa. Chorda tympanic nerve crosses the pars flaccida from inside. Pars flaccida being weaker in strength has tendency to rupture which leading to perforation of the eardrum. Tension of the tympanic membrane is due to the pull of the tensor tympani muscle which is attached to the upper part of the handle of the malleus.

**Figure 286** Showing otoscopic view of tympanic membrane



**Structure of Tympanic Membrane:** Tympanic membrane is the fibrous membrane sand-witched between the skin outside and the mucous membrane inside. Outer layer is lined by the skin which presents stratified squamous epithelium while the mucous layer inside is lined by low columnar ciliated epithelium. Fibrous part of the tympanic membrane is absent in the area of the pars flaccida. This area is filled by the loose areolar tissue. (Pars flaccida is also known as the Shrapnel's membrane) Fibrous part of the tympanic membrane presents circular, radial and the parabolic fibres.

**Relations of the External Acoustic Meatus:**
*Superior:* Middle cranial fossa
*Inferior:* Parotid gland.
*Anteriorly:* Temporomandibular joint.

**Blood Supply:** Deep auricular branch of the maxillary artery supplies the outer surface of the tympanic membrane while the inner surface is supplied by anterior tympanic branch of the maxillary artery and the posterior tympanic branch of the stylomastoid artery which is a branch of posterior auricular artery. It is also supplied by the branch of the ascending pharyngeal and the twigs from the middle meningeal artery.

**Venous Drainage:** Venous drainage of the external surface of the tympanic membrane goes to the external jugular vein. Veins from the inner surface drain into various venous plexuses near the auditory tube and also goes to the transverse sinus.

**Lymphatic Drainage:** It goes to pre-auricular and retropharyngeal nodes.

**Nerve Supply (Outer surface):** Nerve supply of the tympanic membrane is from:

1. Auriculo-temporal and
2. Auricular branch of the vagus (Nerve of Arnold).

Auriculo-temporal nerve supplies the antero-inferior part of the tympanic membrane while the auricular branch of the vagus supplies the postero-superior part.

**Nerve Supply (Inner surface):** The inner surface of the tympanic membrane is supplied by the tympanic branch of the glossopharyngeal nerve (Nerve of Jacobson) through the tympanic plexus.

**Clinical:** Outer surface of the tympanic membrane can be seen with the help of an autoscope. It looks thin and translucent.

**Ramsay Hunt Syndrome :** Ramsay Hunt syndrome is due to the herpes zoster (viral) infection of the geniculate ganglion of the facial nerve. Vesicular eruptions are seen in the area of the auricle and external acoustic meatus which is supplied by the auricular branch of the vagus. It is due to the fact that some of the branches of the facial nerve supply the skin of the auricle through the vagus. (auricular branch of vagus).

**Furuncle :** It is the inflammation of the hair follicle in the cartilaginous part of the meatus. It presents with severe pain as the skin of the meatus is firmly adherent to the pericondrium.

**Wax :** Excessive production of wax forms a plug in the meatus. When it gets dried patient experiences the sense of ear obstruction, giddiness and tinnitus. It is known that the stimulation of the auricular branch of the vagus either during manipulation for removing the impacted wax or during syringing of the ear gives rise to reflex coughing which is known as the ear cough. The lingual, inferior alveolar and the auriculo-temporal nerves are the branches of the mandibular nerve. Carcinoma of tongue or the caries of the lower teeth causes reflex pain in the ear in the area supplied by the auriculo-temporal nerve.

**Pre-auricular Sinus:** External ear develops from the auricular tubercles arising from the first and the second branchial arches. Their partial union leads to formation a sinus. It can be excised surgically.

| | |
|---|---|
| **Bat's Ear:** | The ears are protruding. If not operated they can be concealed by changing the hairstyle. |
| **Treacher Collins Syndrome:** | In this condition the external ear is hypoplastic along with the middle ear, eyes, maxillae and the mandible. |
| **Seroma (Psuedocyst of the Pinna):** | It occurs due to trauma. The swelling is painless and contains straw coloured fluid. |
| **Otitis Externa:** | It is the inflammation of the external ear and it can be acute or chronic. |
| **Myringitis:** | It is the infection of the external surface of the tympanic membrane. It causes severe pain and deafness. |
| **Foreign Bodies:** | They can be living or nonliving. |
| **Living:** | Such as insects |
| **Nonliving:** | Such as peas, wheat. |
| **Cauliflower Ear:** | It is seen in boxers. |

# MIDDLE EAR

Middle ear is situated in the petrous part of the temporal bone, between the external ear laterally and the internal ear medially. Anteriorly it communicates with the nasopharynx through the pharyngo-tympanic tube and posteriorly with the tympanic antrum and so with the mastoid air cells through the aditus of the antrum. Lateral and the medial walls are bulging inwards giving a biconcave appearance to the tympanic cavity. Its height and anteroposterior diameter are equal (15 mm). Transverse diameter at the roof is 6 mm at the middle is 2 mm and at the floor is about 4 mm (Figures 287 and 289).

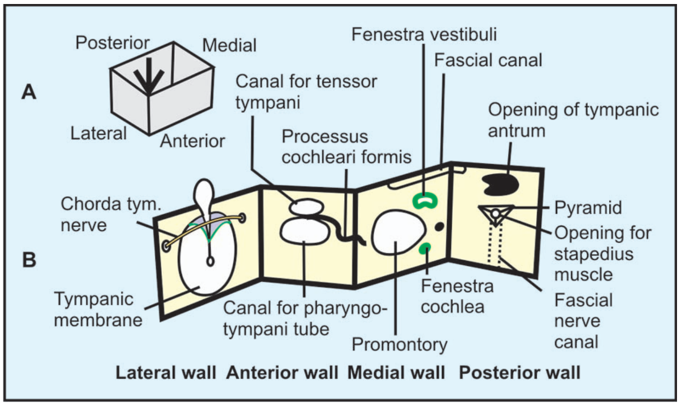



**Figure 287** Schematic drawing to explain the walls of the middle ear with the help of opening of a cardboard box (A) indicating the site of opening and spread-up as shown (B)

**Mucous Membrane:** Mucous membrane has no mucous glands, and is continuous with the pharyngeal mucous membrane and the mucous membrane of tympanic antrum and the mastoid air cells.

**Middle Ear:** It can be compared with the closed card-board box having roof, floor and anterior, posterior medial and lateral walls.

**Roof (Figure 288):** It is formed by the thin plate of bone known as tegmentympani. It covers the roof of the pharyngo-tympanic tube anteriorly and of the tympanic antrum posteriorly. It separates the cavity from the temporal lobe of brain and meninges. In case of children, as the roof is cartilatenous, infection of the middle ear cavity (otitis media) may reach the meninges and cause meningitis.

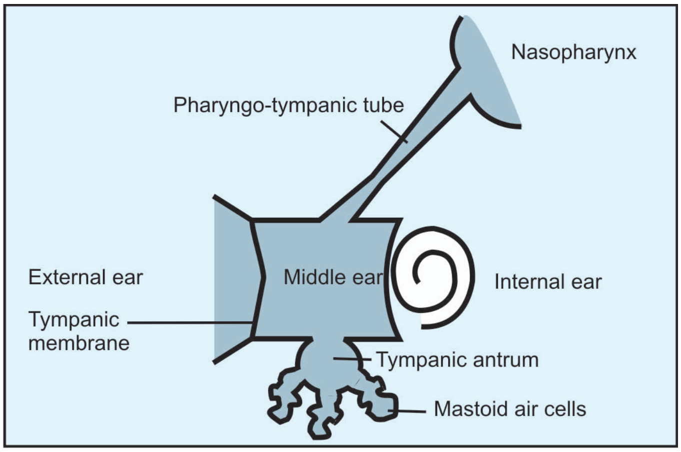
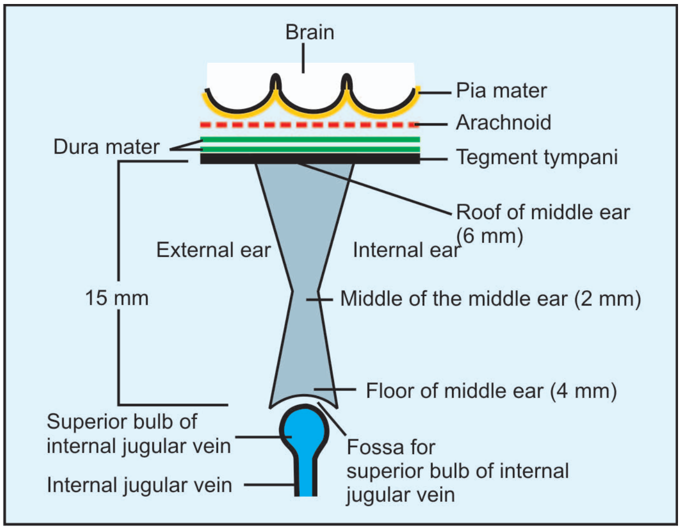



**Figure 288** Showing external, middle and internal ears and communication of the middle ear with the tympanic antrum and mastoid air cells posteriorly and nasopharynx anteriorly (highly schematic)

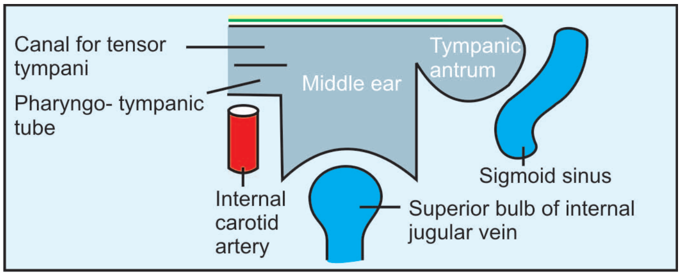
**Figure 289** Coronal section through the middle ear showing relations of roof and the floor




**Floor:** It is formed by the fossa for the superior bulb of the internal jugular vein. Thin plate of a bone separates the cavity from the bulb of the internal jugular vein. Sometimes this bony plate is missing and only the mucous membrane separates the cavity from the bulb. This may lead to thrombosis of the internal jugular vein in cases of otitis media.

**Anterior wall (Fig. 290):** Lower part presents a thin plate of bone which separates the cavity from the internal carotid artery. This plate has small openings for the superior and inferior caroticotympanic nerves and tympanic branch of internal carotid artery. In the upper part of the anterior wall there are two openings placed above one another. Upper opening is that of the canal for the tensor tympani and the lower one for the pharyngo-tympanic tube. Partition between the openings runs backwards, medially in the tympanic cavity to form a small hook, around which the fine tendon of tensor tympani muscle hooks and turns laterally for its insertion into the handle of the malleus. This bony hook like process is called as processus cochleariformis.

**Figure 290** Sagittal section to the middle ear cavity




**Lateral Wall:** Lateral wall presents the tympanic membrane and the epitympanic recess.

**Epitympanic Recess:** A part of the tympanic cavity above the level of the tympanic membrane is known as the epitympanic recess. It contains head of malleus and the body of the incus.

Chorda tympani nerve runs across the tympanic membrane along its flaccid part under the mucous membrane. During the course the chorda tympani runs between the incus medially and the neck of the malleus laterally. Anterior and posterior canaliculi for the chorda tympani nerve and the petrotympanic fissure are seen on the lateral wall.

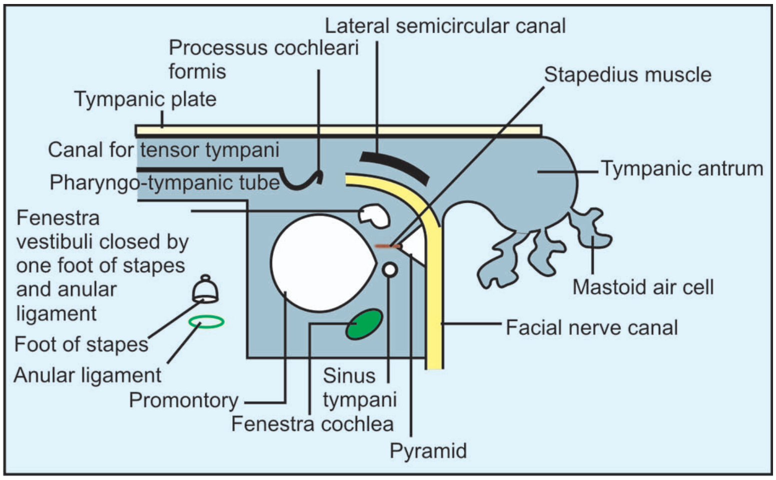
**Medial Wall (Figure 291):** Medial wall is formed by the lateral wall of the internal ear. It presents following structures.

1. Promontory
2. Fenestra vestibule

3. Fenestra cochlea,
4. Facial nerve canal.
5. Tympanic plexus
1. *Promontory:* Promontory is produced by the first turn of the cochlea. It is broad anteriorly and narrow posteriorly. The surface of the promontory presents fine grooves for the tympanic plexus.
2. *Fenestra vestibula:* Fenestra vestibula is situated above and behind the posterior end of the promontory. It is kidney shaped with its hilum pointing downwards.

   It is closed by the foot of stapes along with the annular fibrous ring. It opens in the vestibule of the internal ear.
3. *Fenestra cochlea:* Fenestra cochlea is situated below and behind the posterior end of the promontory. It is round or somewhat oval and leads to the cavity of the cochlea. It is closed by the secondary tympanic membrane.
4. *Facial canal:* Facial canal runs posteriorly above the promontory and the fenestra vestibuli descends downwards behind the pyramid on the posterior wall. The bony wall of the canal when deficient, the facial nerve gets involved in otitis media.

**Figure 291** Showing medial wall of the middle ear. Please note the processus cochleari formis




**Posterior Wall:**

1. *Pyramid:* Pyramid is the hollow bony structure situated on the posterior wall of the middle ear infront of the verticle course of the facial nerve canal. Tendon of stapedius muscle leaves the apex of the pyramid and gets inserted into the neck of the stapes.
2. *Aditus to tympanic antrum (Figure 290):* It is an opening connecting the middle ear cavity and the tympanic antrum posteriorly. Medial wall of the aditus has a prominence produced by the lateral semi-circular canal.
3. *Fossa incudius:* Fossa incudius is placed in the postero-inferior part of the epitympanic recess. It lodges the short process of the incus with its ligament.
4. *Posterior opening of the chorda tympani:* Posterior opening of the chorda tympani nerve lies the junction of the lateral and the posterior walls.

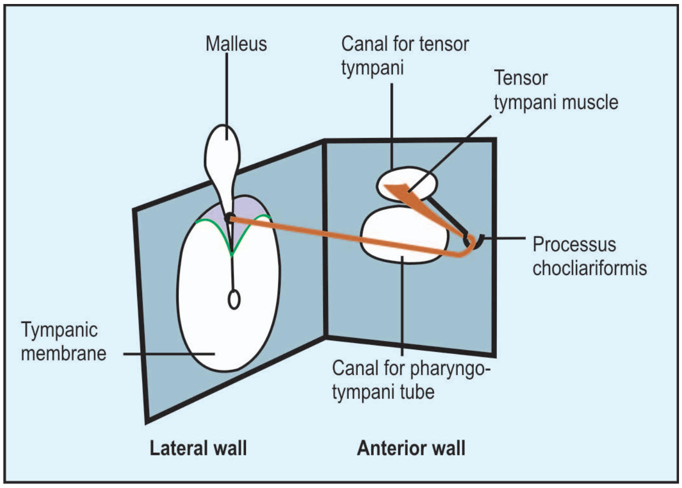
*Contents of the tympanic cavity:*

1. *Bones* – Malleus, incus and stapes.
2. *Muscles* – Tensor tympani and the stapedius.
3. *Nerves* –chorda tympani and tympanic plexus formed by the tympanic branch of glossopharyngeal nerve.

4. *Arteries:* Tympanic branch of maxillary, stylomastoid branch of posterior auricular, petrosal branch of middle meningeal, tympanic branch of ascending pharyngeal and the carotico-tympanc branches from the internal carotid artery.
5. *Veins:* Join superior petrosal sinus and pterygoid venous plexus.

**Tensor Tympani (Fig. 291A):** Tensor tympani arises from the cartilaginous part of the auditory tube and part of the greater wing of sphenoid, and the bony canal in which it lies. It is slender tendon hooks around the processus cochleariformis to turn laterally for its insertion into the handle of the malleus near its root.

**Figure 291A** Showing tensor tympani muscle




**Nerve Supply:** It is supplied by a branch of the nerve to the medial pterygoid muscle through otic ganglion.

**Action:** Tenses the tympanic membrane. This action also helps in pushing the foot of the stapes tightly into the fenestra vestibuli. Stapedius opposes this action of tensor tympani.

**Stapedius:** Stapedius arises from the wall of the cavity of the pyramid and also from further extensions of the canal which descends in front of the 7th nerve canal. Tendon leaves the apex of the pyramid and gets inserted into the neck of the stapes.

**Nerve Supply:** By branch of 7th nerve.

**Action:** Contracts reflexly with the tensor tympani in order to have a protective effect upon sound vibrations reaching the internal ear.

**Tympanic Antrum (Mastoid Antrum):** Tympanic antrum is of a size of the small pea and lies behind the middle ear cavity having communication through the aditus. Its roof is formed by the tengmen tympani, which separates it from the middle cranial fossa. Anterior wall presents an opening which leads to the epitympanic recess. Antero-inferiorly it is related to the verticle course of the 7th nerve. The posterior wall of the tympanic antrum is related to the sigmoid sinus and the carebellar hemisphere. Lateral wall is formed by the squamous part of the temporal bone. It is half an inch thick in case of adults and 1-4 mm thick in case of children. Mastoid air cells open into the antrum. At birth antrum has already reached it adult size. Suprameatal triangle marks the tympanic antrum on the lateral surface of the skull. It is bounded by the supramastoid crest above, tangent drawn along the posterior wall of the external auditory meatus behind and the postero-superior margin of the external auditory meatus anteriorly.

**Note:** At birth the ossicles and the tympanic cavity have reached their full growth. There is no increase in the size of the ossicles or the cavity thereafter.

Mastoid process is absent at birth. It develops during second year of life. However, mastoid air cells develop in the 6th year of life. Facial nerve is likely to be damaged while opening an abscess at the mastoid region in a patient below the age two years of age.

**Clinical:** Acute otitis media
Chronic otitis media

**Complications of Otitis Media:** Relations of the middle ear to the adjoining structures forms the basic cause of complication.

**Roof:** Roof of the middle ear is formed by the tympanic plate. It leads to following complications.

1. Extradural abcess.
2. Meningitis
3. Brain abscess.

**Floor :** Floor is related to the superior bulb of the internal jugular vein. It is separated from the superior bulb of the internal jugular vein by means of the floor of the jugular fossa. Spread of infection of the middle ear can cause thrombosis of the bulb and internal jugular vein.

Posterior to the middle ear is the tympanic antrum mastoid air cells, vertical course of the facial nerve canal and the sigmoid sinus.

Infection can spread to the above structures resulting in:

1. Mastoitis
2. Benzold abscess
3. Thrombosis of the sigmoid sinus
4. Facial nerve involvement.

**Medial Wall:** It is related to the internal ear. Their involvement causes auditory and vestibular dysfunctions.

**Lateral Wall:** Tympanic membrane forms the lateral wall of the middle ear. After the rupture of the ear drum pus discharges through the external ear (Otorrhea– It is the discharge of the pus through the external ear).

**Note:** In spite of the numerous local sources forming the focus of infection the commonest brain abscess is metastatic and mostly from the lung. Therefore, it is wise to have an X-ray of the chest in every case of brain abscess.

**Clinical:**

**Glue Ear:** Glue ear is due to the collection of secretions of ceromucinus gland in the middle ear. Eustachian tube fails to clear the secretions which are formed in the middle ear. It is the painless condition which is commonly seen in children. In cases of cleft palate there is atrophy of tensor palati and levator palati muscles as a result the Eustachian tube fails to open.

**Rupture of the Tympanic Membrane:** Rupture of the tympanic membrane is very important and interesting. Even forceful slap on the ear can cause rupture of the tympanic membrane. It presents with pain, deafness and blood discharge from the ear.

DO NOT TOUCH, NO ANTIBIOTICS, NO EAR DROPS IS THE WISEST WAY OF TREATING THE CONDITION. IT HAS BEEN THE SURGICAL TEACHING IN THE TEXT.

**Tympanoplasty:** Replacement of the tympanic membrane by the homograft of facia.

**Meniere's Syndrome:** It is an interesting symptom complex where the patient presents with unilateral deafness, vertigo, nausea, ringing in the ear (Tinnitus).

**Congenital Deafness:** It is caused by the viral toxins of rubella during the third month of pregnancy. Acquired deafness resulted in large number of cases undergoing treatment of tuberculosis with the drug streptomycine.

**Necrosis of the Tympanic Membrane in Necrotic Otitis Media:** Necrosis of the tympanic membrane occurs at and below the tip of the handle of the malleus. Involving a kidney shaped area of the tympanic membrane. It is due to poor blood supply of the area.

Blood supply of the tympanic membrane is in the form of vascular ring situated at the periphery. Blood vessels follow the malleolar folds and reach the handle of the malleus.

This explains the reason for poor blood supply to the central area of the tympanic membrane.

**Dangerous Otitis Media:** It is attico-antral with marginal perforation. Cholesteotoma is present in the attic and the antrum. In case of its spread beyond the middle ear can cost life (Life threatening).

**Cholesteotoma:** Due to absence of fibrous layer in the pars flaccid of the tympanic membrane the stratified squamous of the external finds it easy to encroach the middle ear cavity even in the absence of perforation of the ear drum. It covers the middle ear with the stratified epithelium. It is known as the skin in the wrong place. Desqamation of cells form concentric layers like onion skin. This is known as cholesteotoma. It is capable of destroying structures in the middle ear due to pressure necrosis and enzymic action.

**Presbycusis:** Loss of hearing in old age due to loss of hair cell of cochlea. Hearing aid is useful.

**Tinnitus:** Abnormal noise in the ear.

**Otosclerosis:** Stapes gets fixed in the oval window due formation of new bone in the annular ligament causing conductive deafness.

It is really paradoxical as a person hears better in noisy atmosphere (such as disco). Removal of the stapes and its replacement by teflon pump graft is the treatment (stapectectomy).

# AUDITORY TUBE

Auditory tube connects the middle ear cavity with the nasopharynx. It makes an angle of 45° with the sagittal plane and of 30° with the horizontal plane. It is 36 mm in length, of which its bony part is in the petrous part of the temporal bone is 12 mm and the cartilaginous part which is situated in a groove between the petrous part of the temporal and the greater wing of the sphenoid, is 24 mm in length. It is directed downwards, forwards and medially. Bony part is situated at a higher plane than the cartilaginous. Junction of the two parts is narrow and is known as the isthmus.

**Bony Part:** It is related to the carotid canal medially and is ablong in cross-section.

**Cartilaginous Part (Figures 292 and 293):** This part is fibrocartilaginous. It consists of a triangular piece of cartilage whose apex is directed laterally and the base medially where it forms a tubal elevation in the lateral wall of the nasopharynx. It is folded to form a larger medial and a smaller lateral laminae. It is open inferolaterally, which is closed by fibrous tissue. Two laminae of the cartilaginous plate are connected by the elastic tissue which helps the closure of the tube. Antero-lateral to the tympanic tube is the pad of fat which is known as Otman's pad of fat. It allows free dilatation of the pharyngeal tympanic tube when required and helps in its closure due to recoil.

Tube is lined by the ciliated columnar type of epithelium. It is thick in the cartilaginous part due to the presence of the mucous glands and extremely thin in the bony part.

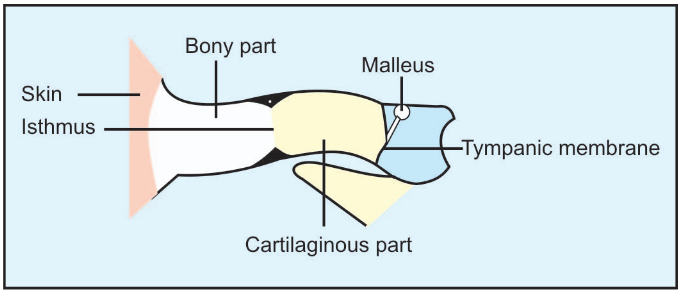



**Figure 292** Showing external auditory canal

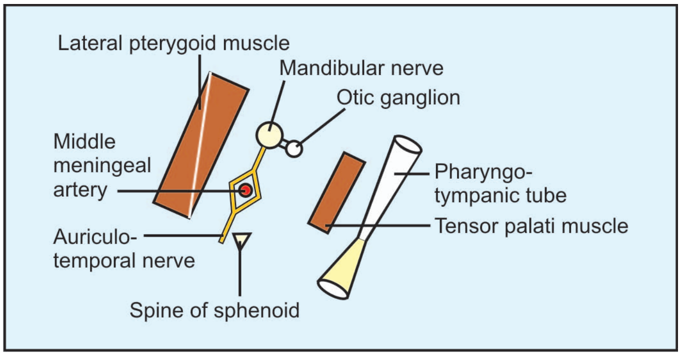



**Figure 293** Showing relations of tensor palati muscle

**Relations:** Antero-lateral relations :

Following structures form the antero-lateral relations of the pharyngo-tympanic tube:

1. Tensor palati muscle,
2. Mandibular nerve
3. Otic ganglion,

4. Chorda tympani nerve,
5. Auriculo-temporal nerve and
6. Middle meningeal artery.

**Postero-medial Relations:** Following structures form the postero-medial relations of the pharyngo-tympanic tube:

1. Levator palati muscle,
2. Petrous part of the temporal bone with opening of carotid canal.

**Muscles related to the Tube:**

1. *Tensor palati:* Tensor palati muscle arises from the scaphoid fossa, medial margin of foramen ovale, base of the spine of sphenoid and the antero-lateral part of the pharyngo-tympanic tube. The part arising from the pharyngo-tympanic tube helps in dilatation of the tube therefore it is called as the dilator tubae muscle. Dilator tubae the part of the tensor palati in association with the salpingo-pharyngeus muscle helps in opening of the tube during swallowing.
2. *Salpingo-pharyngeus muscle:* It arises from the tubal elevation of the pharyngo-tympanic in the lateral wall of the nasopharynx. And runs under the fold of the mucous membrane known as salpingo-pharyngeal fold. It is inserted into the posterior border of the thyroid lamina.

**Tube of the Newborn:** Pharyngo-tympani tube of the newborn differs from that of the adult in following respects.

1. Length of the tube is half that of the adult.
2. Bony part is shorter
3. The course is more or less horizontal.
4. It has no tubal elevation
5. Pharyngeal opening is like a narrow slit.

**Clinical:** Due to the horizontal course of the tube, the nasopharynx and the middle ear cavity in children lie at the same level. Infection from the nasopharynx reaches the middle ear easily. This explains why the middle ear infections (Otitis media) is common in children than in adults.

**Blood Supply:** It is supplied by the following arteries:

1. Ascending pharyngeal branch of the external carotid artery,
2. Middle meningeal artery and
3. The artery of the pterygoid canal.

**Venous Drainage:** Tubal veins drain into the pterygoid venous plexus.

**Nerve Supply:** It is supplied by the tympanic plexus and pharyngeal branches of the pterygo-palatine ganglion.

# INTERNAL EAR

It is an essential organ of hearing and balance. Internal ear consists of two parts, the bony labyrinth and the membranous labyrinth.

Bony labyrinth consists of three parts—vestibule, semicircular canals and the cochlea. They are lined by the periosteum and contains fluid called as perilymph. The membranous labyrinth is situated in the bony labyrinth.

**Vestibule (Figures 294 and 295):** Vestibule is the central part of the bony labyrinth and is situated medial to the tympanic cavity, behind the cochlea and in front of the semicircular canals. Its lateral wall presents an opening which is closed by the foot of the stapes and the anular ligament (Fenestra vestibuli). Medial wall has a small spherical recess, in its anterior part, which lodges the sacule. This recess corresponds to the inferior vestibular area in the bottom of the internal auditory meatus. Vestibular crest is situated behind the recess. Anterior end of it is known as the pyramid of vestibule. Below the crest is the cochlear recess and above it is the elliptical, which lodges the utricle. Pyramid and the adjoining part of the elliptical recess correspond to the superior vestibular area at the bottom of the internal auditory meatus. Opening of the aqueduct of the vestibule is below the elliptical recess. The aqueduct extends to the posterior part of the petrous temporal bone. It contains a tubular prolongation of the membranous labyrinth, ductus endolymphaticus and a small vein. Five openings of the semicircular canals are situated at the posterior part of the vestibule, while the anterior part of the opening leads to the scala vestibule of the cochlea.

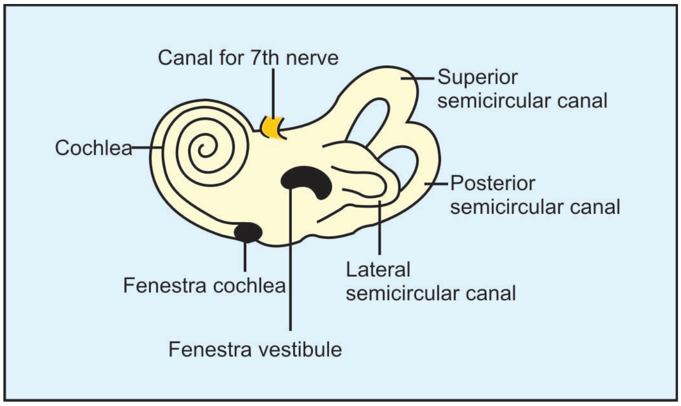



**Figure 294** Showing bony labyrinth

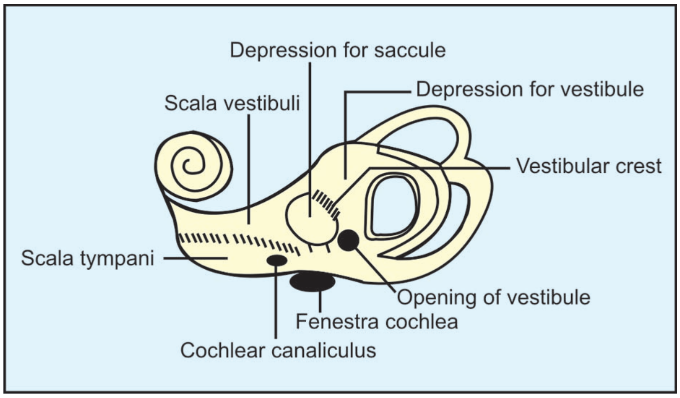



**Figure 295** Showing interior of bony labyrinth

**Semicircular Canals: (Figures 296 to 297A)** They are 3 in number. Superior one lies in a plane at right angles to the long axis of the petrous part of temporal bone while lateral is set in a horizontal plane and posterior canal is parallel to the long axis of the bone.

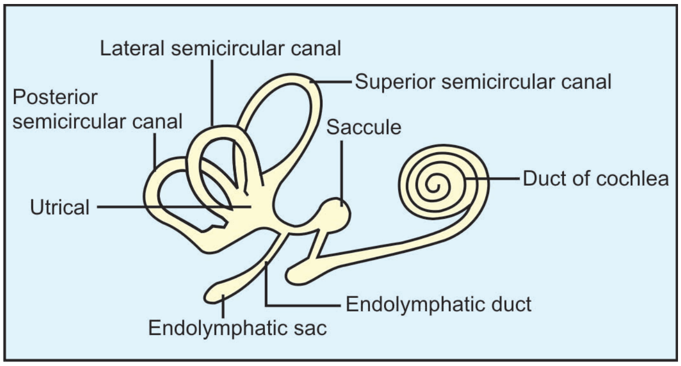



**Figure 296** Showing membranous part of internal ear

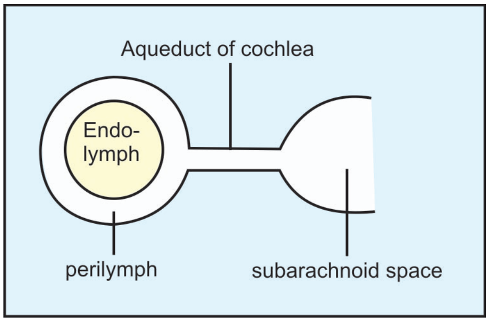



**Figure 297** Showing relation of endolymph and perilymph with each other and the relation of perilymph with subarachnoid space

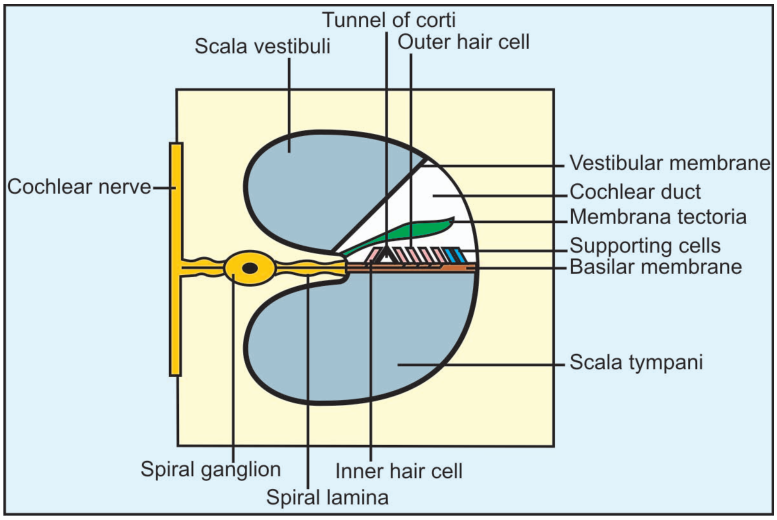



**Figure 297A** Showing internal ear

**Cochlea:** Cochlea consists of a central column known as modiolus. A hollow tube laterally and the base backwards and medially.

**Membranous Labyrinth:** It is situated inside the cavity of the bony labyrinth and is surrounded by perilymph. Membranous duct of the cochlea is highly specialized to form spiral organ (of corti). This is the essential organ of hearing. Spiral ganglion is placed in a canal which winds round the moidiolus in the base of the spiral lamina. Peripheral branches from the ganglion pass to the organ of corti and the cental branches leave the bone through foramina at the bottom of the internal auditory meatus and form the cochlear part of the auditory nerve. Duct of the cochlea opens by narrow ductus reunions into the saccule posteriorly. Saccule is placed in the vestibule.

Semicircular ducts are ampullated at one end, where the epithelium is specialised. All of them open into the utricle. Utricle itself lies in the posterior part of the vestibule. Utricle and semicircular canals are supplied by the branches of the vestibular nerve. Utricle and the saccule are in direct communication with each other. Ductus endolymphaticus opens at the posterior end of the saccule. It is joined by the ductus utriculo-saccularis from the utricle. It ends blindly to form saccus endolymphaticus. It projects through the acqueduct of the vestibule on the posterior surface of the petrous part of temporal bone.

Parts of membranous labyrinth although communicate with each other it is closed and does not have any communication with the subdural or subarachnoid space. It is the perilymph alone which drains into the subarachnoid space through the aqueduct of the cochlea. Acqueduct of the cochlea is the minute canal leading from the scala tympani to the surface of the petrous part of the temporal bone at the upper border of the jugular foramen.

**Development:** Membranous labyrinth is developed from ectodermal plates (placods) opposite the hind brain.

Two thicked surface ectodermal arise bilaterally by the side of rhombencephalon. They are known as otic placode. Otic placode invaginate to form otic vesicles. Vesicle divides into ventral and dorsal component.

Ventral component form (1) Saccule and (2) Cochlear duct.

Dorsal component form (1) Utricle (2) Semicircular canals and (3) Endolypahatic duct.

All the five parts form the membranous labyrinth.

# FACIAL NERVE

Facial nerve is the nerve of the second pharyngeal arch. It runs from the middle of the anterior border of the mastoid process posteriorly to the point behind the neck of the mandible anteriorly. This horizontal direction of the facial nerve must be remembered by the surgeon during incision and drainage of the parotid abscess.

**Functional Components:**

1. *Special visceral-efferent:* To the muscles derived from the second pharyngeal arch.
2. *General visceral efferent :* They are the secretomotor (parasympathetic) to the submandibular, sublingual and the lacrimal glands. It also supplies the glands of the palate, pharynx and the nose.
3. *General visceral afferent :* It carries impulses from the submandibular, sublingual and the lacrimal glands.
4. *Special visceral afferent (Figure 298):* Carries taste sensation from the anterior 2/3rd of the tongue excluding valate papillae. It must be noted here that the taste sensation of the posterior 1/3rd of the tongue including the valate papillae is carried by the glossopharyngeal nerve.

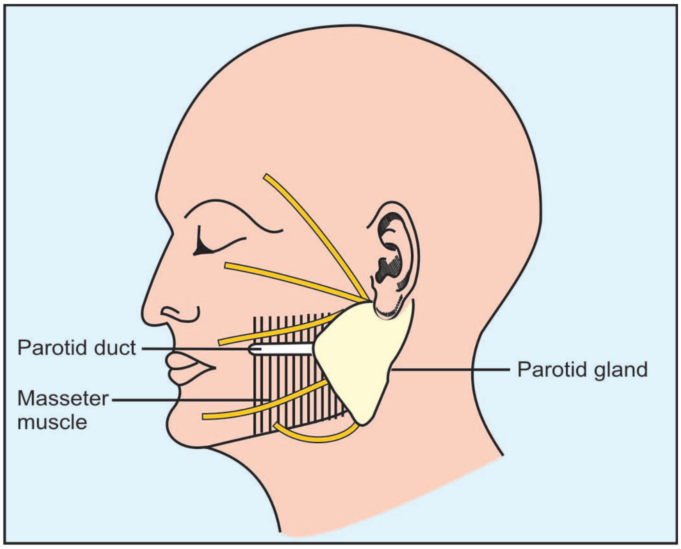
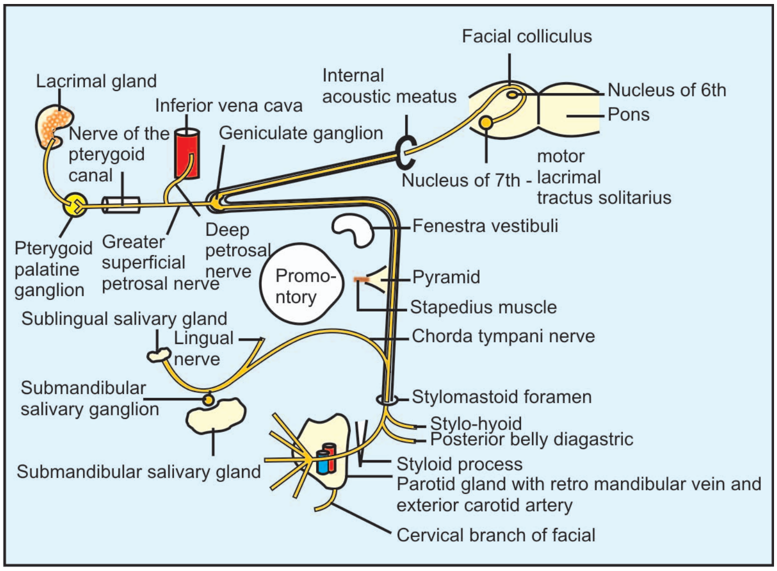



**Figure 298** Showing position of parotid gland

5. *General somatic afferent (Figure 299):* It is well known that the facial nerve has no direct branches to the skin of the ear. However, some fibres of the facial nerve manage to reach the skin of the ear through the vagus nerve (Refer Ramsay Hunt syndrome).

**Figure 299** Showing course and distribution of facial nerve




**Note:** Proprioceptive sensations of the muscles of the face are carried by the mandibular nerve to the mesencephalic nucleus of the fifth in the midbrain.

**Course and Relations:** At the brainstem it presents the motor and the sensory roots. Sensory root is also known as the nervous intermedius. These two roots are attached to lateral aspect of the lower border of the pons medial to the 8th cranial nerve. Two roots of the facial nerve and the 8th nerve go laterally and forwards to the internal acoustic meatus. In the meatus the motor root of the facial lies on the 8th nerve. In between the two is the sensory root. (Nervous intermedius). The course of the facial nerve is mainly divided into intracranial and extracranial parts. Two roots of the facial nerve unite together and form a single trunk which travels through the petrous part of the temporal bone. The facial nerve canal is conventionally divided into three parts presenting two bends. First part of the canal is directed laterally above the vestibule of the internal ear. In its second course it is directed posteriorly above the promontory and the fenesta vestibuli. Third part runs vertically downwards behind the pyramid and ends at the stylomastoid foramen where the intracranial part of the facial nerve ends. Here it lies medial to the mastoid process and lateral to the base of the styloid. It crosses the styloid process from lateral side and enters the posteromedial surface of the parotid gland. In the parotid gland it has a horizontal course superficial to the external carotid artery and retromandibular vein. It divides into five branches which come out along the anterior border of the parotid gland. The branches of the facial nerve are as under:

1. Temporal
2. Zygomatic
3. Buccal
4. Mandibular
5. Cervical

*Branches of the facial nerve inside the canal:*

They are three:

1. Greater superficial petrosal
2. Nerve to the stapedius and
3. The chorda tympani

*Branches outside the canal :*

They are three.

1. Posterior auricular
2. Digastric and
3. Stylohyoid

Terminal branches of the facial nerve are five in number are already mentioned.

**Greater Superficial Petrosal Nerve:** Greater superficial petrosal nerve arises from the geniculate ganglion situated at the first turn of the facial nerve. It leaves the petrous part of the temporal bone through an opening on the anterior surface of the petrous part of the temporal bone in middle cranial fossa. It enters the foramen lacerum and is joined by the deep petrosal nerve which is formed by the sympathetic plexus around the internal carotid artery. The greater superficial petrosal and the deep petrosal unite to form the nerve of the pterygoid canal. Nerve of the pterygoid canal enters the pterygo-palatine fossa and joins the pterygo-palatine ganglion. It contains taste fibres for the palate and parasympathetic fibers for the lacrimal gland. The secretomotor fibres for the lacrimal gland get relayed in the spheno-palatine ganglion through zygomatic branch of maxillary.

**Motor Root:** Motor root supplies the muscles of the face, muscles of the scalp, muscles of the external ear, stapedius, buccinator, platysma, the posterior belly of digastric and stylohyoid.

**Sensory Root:** Sensory root contains the fibres of taste from the anterior two-thirds of the tongue. Secretomotor fibers for the submandibular, sublingual and the lacrimal glands are the component of the sensory root. It consists of central processes of the unipolar cells of the geniculate ganglion. It leaves the trunk of the facial nerve in the internal auditory meatus and passes towards the lower border of the pons along with the motor root and the statoacoustic nerve. From the nucleus the nerve fibres run medially and wind around the nucleus of 6th under the facial colliculus in the floor of the fourth ventricle. It runs laterally and forwards to appear at the lower border of the pons.

**Sensory Nucleus:** Sensory nucleus is the upper part of the nucleus of the tractus solitarius.

**Branches :**

1. Branches of communication, and
2. Branches of distribution.

**Branches of Communication:**

1. With statoacoustic nerve,
2. With pterygopalatine ganglion through the greater superficial petrosal nerve.
3. With the otic ganglion by the branch through the lesser superficial petrosal nerve.
4. With sympathetic plexus of the middle meningeal artery.
5. With the auricular branch of vagus (nerve of Arnold).
6. With the glossopharyngeal, vagus, great auricular and the auriculo-temporal nerves.
7. It also gives communicating branches to the lesser occipital, trigeminal and the anterior cutaneous nerve of the neck.

**Branches of Distribution:**

1. *Nerve to stapedius:* arises opposite the pyramid.
2. *Chorda tympani:* arises from the vertical part of the canal 6 mm above the stylomastoid foramen.
3. *Posterior auricular:* arises nearer the stylomastoid foramen. It divides into auricular and occipital branches. Occipital branch supplies the occipital belly of occipitofrontalis.

4. *Digastric branch:* arises close to the stylomastoid foramen.
5. *Stylohyoid branch:* frequently arises in common with the digastric branch.
6. Temporal branches :
7. Zygomatic branch :
8. Buccal branches :
9. Mandibular branch
10. Cervical branch

The branching pattern of the facial nerve looks like the goose foot (pes anserinus).

Landmarks of the facial nerve relations:

Short process of incus

Facial nerve lies medial to the short process of incus.

*Pyramid:* The nerve passes behind the pyramid.

*Tympanomastoid suture:* Nerve runs behind the suture.

*Diagastric ridge:* Facial nerve leaves the mastoid process at the anterior end of the diagastric ridge.

*Styloid process:* The nerve crosses the styloid process superficially.

**Posterior Belly of Digastric (Figure 300):**

It is the key muscle for the surgeons operating on the neck as important structures of the neck are under the posterior belly of digastric such as:

1. The internal jugular vein
2. Accessory nerve
3. Vagus nerve
4. Hypoglossal nerve
5. Internal carotid artery
6. External carotid artery
7. Lingual artery and
8. Facial artery
9. Along the lower border of the posterior belly of the digastric the occipital artery and along the upper border runs the posterior auricular artery.

If the posterior belly of the gastric muscle is searched posteriorly along its superior border to its origin, the facial nerve is found between the digastric notch laterally and the styloid process medially.

**Clinical:**

In case of facial nerve injury following features or signs are noted –

1. Inability to close the eyelid
2. Upward rolling of eyeball
3. Exposure keratitis
4. Flattening face
5. Collection of food inside the cheeck
6. Dribbling of saliva
7. Inability to whistle

**Facial Nerve Paralysis:**

It is classified into three according to the anatomical positions.

1. *Supranuclear :* Cortical fibres of both the sides reach the nucleus, which supplies the muscles of the upper part of the face above the palpebral fissure. Therefore, only the muscles below the palpebral fissure are paralysed. Supranuclear lesion is due to involvement of the cortico-bulbar pathway due to cerebral haemorrhage.
2. Nuclear type of facial paralysis is due to poliomyelitis.
3. Infranuclear type of lesion is due to compression of the facial nerve in the cerebello-pointine angle which could be due to acoustic neuroma.

4. Fracture of the temporal bone and the malignancy of the parotid gland also produce infranuclear facial paralysis.

**Comment:** The commonest facial paralysis due to Bell's the aetiology of which is unknown. When the intracranial part of the nerve is involved in the fracture of the base of skull, there is loss of taste of the anterior 2/3rd of the tongue associated with deafness.

In upper motor neuron type of paralysis, patient can close the eye and wrinkles the forehead. In lower motor neuron lesion all the muscle supplied by the facial nerve are paralysed which leads to complete facial weakness, loss of tone and the facial expressions. Facial nucleus also receives fibres from the thalamus by different root. It provides involuntary control of the facial muscles, due to this the emotional movements like smiling and crying are maintained in the supranuclear lesion of the facial nerve.

Sensory root is also known as the nerve of Wrisberg. It carries secretory fibres for the submandibular, sublingual and the lacrimal glands. It also carries taste fibres from the anterior 2/3rd of the tongue. It also carries the fibres from the skin of the concha and the retroauricular part.

**Causes of Facial Nerve Injury:**

1. *Central:* Cerebrovascular episode
2. Cerebellar pontine angle tumors (acoustic neuroma)
3. Bell's palsy (Lower motor neuron type of lesion)

   Some other causes of lower motor neuron, i.e. infranuclear are as under:
   1. Meningitis – usually tubercular
   2. iatrogenic – due to dehiscene of facial canal, instillation of local anaesthetic drops can cause temporary paralysis of the facial nerve.
3. Lead poisoning.
4. Complication of acute and chronic dangerous otitis media.
5. Lower posterior auricular incision in children below two years (Please recollect the development of the mastoid process which occurs in the second year of life.
6. Herpes zoster (Ramsay Hunt syndrome)

**Note:** Conventionally five branches of the facial nerve are mentioned in the text. However, additional marginal mandibular branch of the facial should also be described.

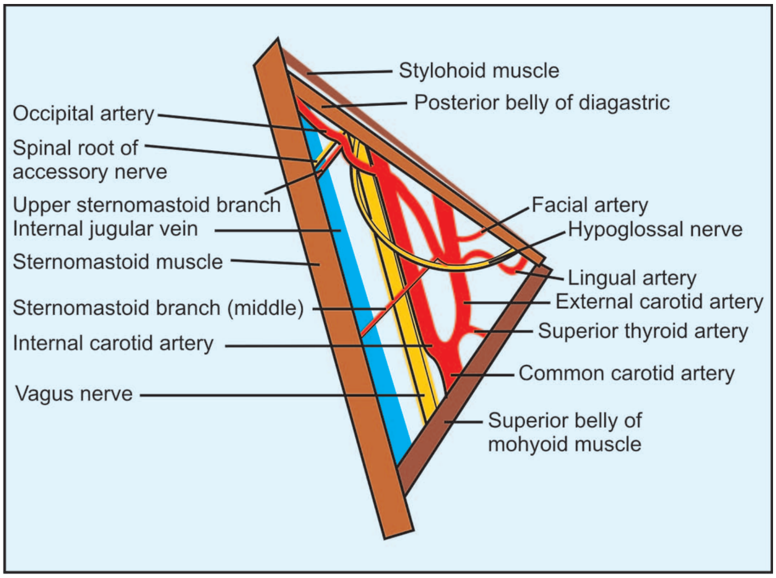
**Facial Tic:** In this condition there is repeated spasm of the facial muscles producing localized twitching or winking. Section of the particular branch of facial nerve helps in relieving the symptoms.

**Statoacoustic Neuroma or 8th Nerve :** It is soft and devoid of neurolemma in its proximal part. It consists of vestibular nerve and the cochlear nerve respectively performing the functions of balance and hearing. Vestibular division arises from the cells of the vestibular ganglion situated in the bottom of the internal auditory meatus. Cochlear nerve arises from the cells of the spiral ganglion of the cochlea.

**Vestibular Nerve:** Vestibular nerve enters the brain medial to the cochlear nerve at the higher level. They pass backwards through the pons between the inferior cerebellar peduncle and the spinal tract of the trigeminal. They divide into ascending and descending branches which end in the vestibular nuclei. However, some of them may pass directly to the cerebellum through the inferior cerebellar peduncle.

**Cochlear Nerve:** At the brainstem it lies lateral to the vestibular nerve. In its further course it is separated from the vestibular nerve by the inferior cerebellar peduncle. Cochlear nerve goes lateral to the peduncle and the vestibular nerve is ventral and medial to it. It has the dorsal and the ventral nuclei. Efferent

**Figure 300** Showing carotid triangle and contents. Note that hypoglossal nerve crosses three artries namely internal, external and lingual arteries




fibres from the ventral nucleus end in the dorsal nucleus of the corpus trapezoideum either on the same or of the opposite side. After relay third neuron starts. Fibres ascend in a compact bundle, which is known as lateral temniscus. Efferent fibres from the dorsal nucleus has similar arrangement. On reaching the midbrain some of the fibres end in the inferior corpora quadrigemina, while others directly pass to the medial geniculate body. From here they are relayed and proceed to the auditory cortex.

# NUCLEI OF SOME OF THE CRANIAL NERVES

**Oculomotor:** It supplies all the ocular muscles (except the superior oblique and lateral rectus) and sphincter pupillae and the ciliary muscles through the ciliary ganglion.

**Nucleus :** It lies in the grey matter of the upper part of the floor of the aqueduct of the midbrain at the level of the superior corpora quadrigemina. It has a dorsilateral nucleus, ventrimedial nucleus, Edinger-Westphal nucleus central and caudal central nucleus. Ediger-Westphal nucleus is regarded as the nucleus of origin of the fibres which innervate the sphincter and ciliary muscles. Fibres run forwards through the tegmentum, red nucleus and substantia nigra to appear on the medial side of the cerebral peduncle.

**Trochlear Nerve:** Nucleus is situated in the floor of the aqueduct of the midbrain at the level of the inferior corpora quadrigemina. Fibres take a peculiar course. They run downwards and laterally through tegmentum and turns backwards round the central grey towards the superior medullary vallum, where they cross the midline and appear on the dorsal surface of the midbrain posterior to the inferior corpora quadrigemina.

**Abducent Nerve:** Nucleus of the abducent nerve is situated in the upper part of the floor of 4th ventricle near the median plane under the facial colliculus in the pons. Fibres of the 7th nerve wind around the nucleus of the 6th from medial to lateral side. After emerging from the nucleus, fibres run forwards and downwards through the pons to appear on the surface between the lower border of pons and the upper border of pyramid.

# STRUCTURE AND DEVELOPMENT OF TOOTH

## Tooth

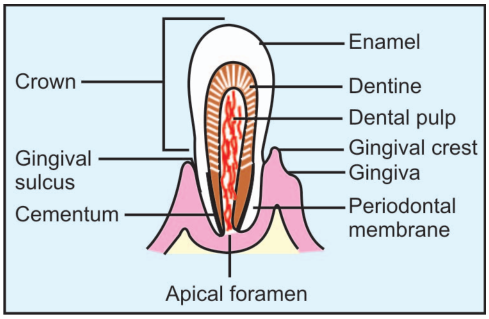
Tooth is one of the hardest structures of the body. It has mainly three parts, namely the expanded free portion known as the crown, the narrow embedded portion, the root and the middle the neck. Mandible and maxilla are provided with the alveolar sockets for the teeth. Root of the tooth is fixed by the periodontal membrane. Periodontal membrane being fibrous in nature, the joint formed is known as gamphosis, a fibrous variety of joint.

Alveolar process is covered with the mucous membrane known as gum. Gingiva is the gum tissue which project from the socket over the tooth.

Longitudinal section of the tooth reveals the central cavity, the dental pulp. It contains connective tissue, vessels and the nerves. Its wall is formed by a hard structure known as dentine, which is a calcified material. Its protoplasmic process forms the odontoblast. Enamel is the hardest tissue of the body. It contains crystalline prism. They are placed at right angle to surface of the tooth.

Enamel covers the crown and the cement covers the root. The gap between the gingival crest and the tooth is known as gingival sulcus. Here small particles of food can accumulate and the calcium from the saliva can form the tarter. Bacterial action on the small particles of food is said to form acids which results in decalcification of enamel. Cavities thus formed in the tooth are known as caries. Infection and oedema of the pulp cavity lead to the death of the pulp (Figure 301).

**Figure 301** Showing structure of tooth




**Eruption of Teeth (Figures 302 to 306):** Incisor are for cutting, canines for holding and tearing and the molar are for grinding. They have four to five cusp on their crown. Premolar are bicuspid. Lower premolar has one root while the upper premolar has two roots, upper molar have three roots while the lower motors have only two roots.

**Figure 302** Showing development of tooth

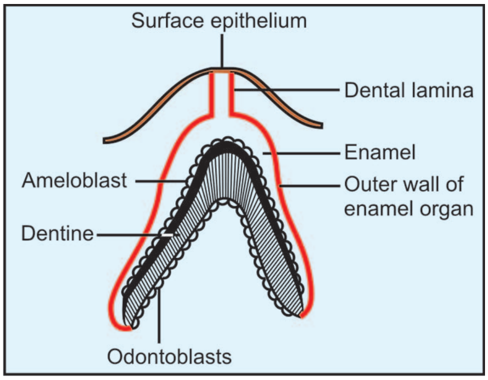


**Figure 303** Development of tooth I

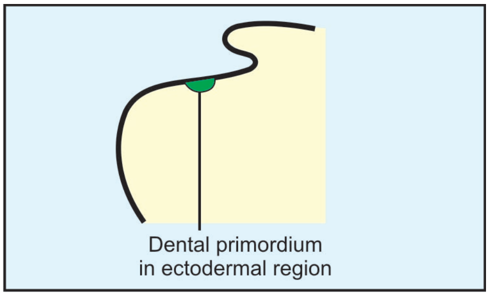



**Figure 304** Development of tooth II

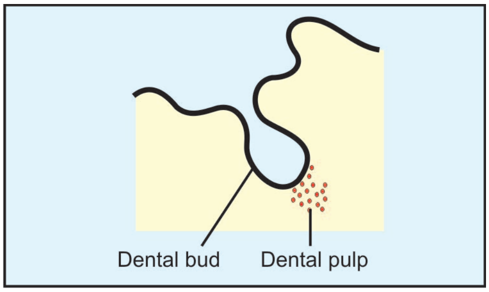



**Figure 305** Development of tooth III

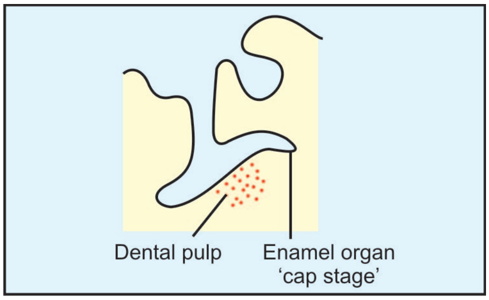
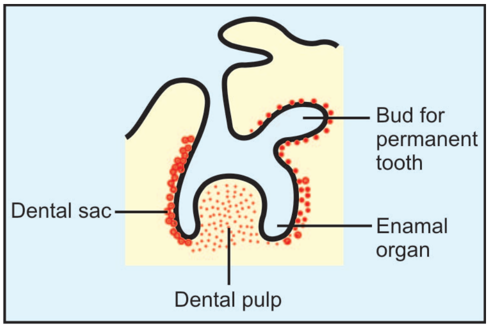



**Figure 306** Development of tooth IV




**Dentition :** Two sets erupt during the primary dentition, 5 in each half. Starting from midline towards distal end of the arch they are as under:

1. Medial incisor
2. Lateral incisor
3. Canine
4. First molar
5. Second molar.

There are 32 teeth in permanent dentition, 8 in each half of the arch. They are as under:

1. Medial incisor - 7 years
2. Lateral incisor - 8 years
3. Canine - 11 years
4. First premolar - 9 years
5. Second premolar - 10 years
6. First molar - 6 years

7. Second molar - 12 years
8. Third molar - (wisdom tooth 17-25 years)

**Time of Eruption:** Age at which the various teeth erupt is important.

Lower central incisor 6 month, upper central incisor 7month, lateral incisor, 7-9 months, first molar one year. Canines 18 month and second molar 2 years.

**Milk Teeth:** First tooth to erupt is the lower medial incisor. Lower teeth appear earlier than the corresponding upper. Canine erupts between the erupted teeth. It also gives more trouble to the baby. It is not uncommon to find that practically any illness of baby at this age is attributed to this by the mothers and often valuable time is lost before a physician is consulted.

**Permanent Teeth:** Here two canines appear between erupted teeth (Here there are two erupted teeth on either side). Once baby starts taking solid food, child continues to do so, even during the period of change over the dentition. Again, 6 years growth is required to provide the space for each molar.

**Development of Tooth:** Dental premordium appears in the horseshoe shaped line in the floor of the oral cavity between lingual and labial swellings at about 6-7 weeks of intrauterine life. This is an ectodermal thickening. At the side of future tooth, rate of proliferation is more. This results in forming dental bud which grows into the mesoderm. The convex end of the bud gets invaginated to form the cup. The cup is double walled epithelial structure known as enamel organ. It becomes bell-shaped. The connection between the enamel organ and the dental lamina disappears. On the lingual side of the enamel organ at its junction with the dental lamina another bud appears for the permanent tooth. Mesoderm surrounding enamel organ is known as dental sac. Outer layer of the enamel organ is formed by the enamel epithelium. It is continuous around the rim of bell with the inner layer of the organ.

Basement membrane of the inner layer is in contact with the mesoderm of the dental papilla. The only important layer is the layer of ameloblast which forms enamel and enduces the adjacent mesodermal cells of the dental papilla to assume columnar type of odontoblast. Thus, the basement membrane separates two types of blast cells. Dentine is developed and deposited on either side of the membrane. Ameloblast are like hexagonal rods. Basal portion of these cells become granular and get converted into the enamel. This process is cyclical which results in the formation of striae of Ritzus seen in the ground section of the tooth.

Odontoblast are mesodermal cells and like oesteoblast can form intercellular substance which gets calcified. Cytoplasmic processes remain in contact with the basement membrane. Intercellular substance, is deposited around these processes, which is like the osteoid tissue. This is predentine which gets calcified. Processes of the odontoblasts remain in the form of Tome's dentinal processes and the canals in which they lie are called dentinal tubes.

For the development of the root, ameloblasts have to migrate beyond the rim of the bell to induce the odontoblast. They form tubes around the deeper mesoderm and to start with, the tube is continuous with the rim of the bell. After the formation of the odonoblast the cells of the tube get detached from the rim of the bell and get loosened in the surrounding mesoderm of the dental sac. This persists as epithelial rests of Malassez. These cells as well as those persisting from the dental lamina may give rise to dental cysts. Rest of these cells of the sac from collagen fibres of the periodontal membrane. Outer ends of the collagen fibres get embedded

into the bone. These fibres are known as Sharpey's fibres. They are longer than the distance between their attachments. This grants a limited mobility to the joint.

**Clinical Highlights of Tooth:**

1. *Enamel:* It is the toughest tissue in the body covering the crown of tooth. Fully formed crown has nonviable cells as the ameloblasts. Cells laying enamel matrix get degenerated once its function is over. Enamel is completely formed before the tooth erupts and it is lost because of wear and tear or carious process. It is lost for ever as it cannot be replaced naturally.
2. Genetic and environmental factors affecting the normal synthesis and secretion of the enamel are affected by infections, nutritional deficiency, excessive fluoride in water and tetracycline. They lead to formation of hypoplastic enamel.
3. Patient with congenital syphilis shows notch in central incisor which is called as Hutchinson incisor.

**Dentine:** Nerve endings are present in the inner layer of dentine. When dentine is exposed it becomes sensitive to hot and cold beverages. Unfortunately pain is the symptom of caries which occurs only when the pulp is already involved and down with pulpitis.

**Root Canal Treatment:** As already stated the process of caries is painless in enamel and initial layer of dentine. Pain occurs because the carious process has already reached the pulp causing irreversible pulpitis which needs treatment in the form of removal of infected pulp tissue, i.e. called root canal treatment. Infected pulp tissue is excised with specialised technique and the root canal space is made sterile, i.e. free from microbes. The canal is filled with various dressing material and now this sterile root canal space is filled with some inert material to prevent re-infection.

If the pulpitis is not treated it forms periapical abscess which may spread to the tissue spaces leading to serious complications like Ludwig's angina, cavernous sinus thrombosis and meningitis.

**Summary of the Development of Tooth:** Tooth develops from two sources.

1. Enamel develops from the ectoderm.
2. Rest of the tooth is developed from the mesoderm.

**Nasmyth's Membrane:** Remaining cells of the ameloblast remain as a fine cover (Enamel cuticle) for the tooth at the time of eruption. This is known as Nasmyth's membrane.

**Clinical:** Dental health in our country is neglected. It is mainly due to neglect of oral hygiene. Chewing pan, tobacco with slaked line and ghutka help in increasing the incidence of early loss of the teeth, after caries (Death of the pulp), pyorrhoea and even the cancer. Vitamin C deficiency causes hypertrophy of the gums which on touch bleeds. Death of the pulp leads apical abscess which be seen in a good dental film. Teeth can help in deciding age of an individual. Golden or silver tooth helps the identification of the dead.

# NUCLEAR COMPONENTS OF CRANIAL NERVES

**Olfactory—the First Cranial Nerve:** Part of forebrain.

**Optic—the Second Cranial Nerve:** Part of forebrain.

**Oculomotor Nerve—Third Cranial Nerve:**
1. Five extraocular nerves are supplied by the general somatic efferent.
2. Two sets of intraocular muscles get general visceral efferent fibers.
3. Proprioceptive impulses from the extraocular muscles go through general somatic afferent to the spinal nucleus of the fifth.

**Trochlear—fourth Cranial Nerve:**
1. *General somatic efferent*—column for the supply of only superior oblique muscle.
2. *General somatic afferent*—spinal nucleus of 5th cranial nerve. It receives proprioceptive impulses from the superior oblique muscle.

**Trigeminal—fifth Cranial Nerve:**
1. Four muscles of mastication and additional four muscles are supplied by special visceral efferent column.
2. General somatic afferent.
   a. Spinal nucleus of CNV for pain and temperature from face.
   b. Superior sensory nucleus of CNV for touch and pressure from face.
   c. Mesencephalic nucleus of CNV for proprioceptive impulses from extraocular muscles and muscles of mastication.

**Abducent—sixth Cranial Nerve:**
1. General somatic efferent for lateral rectus.
2. General somatic afferent—spinal nucleus of the cranial nerves V. It receives proprioceptive impulses from the lateral rectus muscle.

**Facial: Seventh Cranial Nerve**
1. Special visceral efferent for muscles of face.
2. General visceral efferent for lacrimal, nasal, palatal and submandibular and salivary glands.
3. Special visceral afferent and general visceral afferent (nucleus of tractus solitarius) for carrying taste from most of anterior two-thirds of tongue and afferents from glands supplied by it.
4. General somatic afferent from part of skin of auricle.

**Vestibulocochlear—8th Cranial Nerve:**
1. Special somatic afferent column:
2. *Two parts:* Vestibular nuclei: Medial, superior, spinal, lateral
3. *Cochlear nuclei:* Dorsal and ventral.

**Glossopharyngeal—9th Cranial Nerve:**
1. Special visceral efferent for one muscle of pharynx – the stylopharyngeus.
2. General visceral efferent for parotid gland
3. Special and general visceral afferent (nucleus of tractus solitarius) for sensations of taste from posterior one-third tongue and circumvallate papillae. Also carries general sensations from posterior one-third tongue, carotid body and carotid sinus.
4. General somatic afferent for proprioceptive fibres from the muscle stylopharyngeus.

**Vagus and Cranial Part of Cranial Nerve—11th Nerve:**
1. Special visceral efferent for muscles of larynx, pharynx and soft palate.
2. Special and general visceral afferents carry (nucleus of tractus solitarius) taste from posterior most part of tongue, epiglottis and afferents from foregut and midgut derivatives.
3. General visceral efferent for glands of respiratory system and gastrointestinal tract till right two-thirds of transverse colon.

4. General somatic afferent from skin of external auditory meatus.

**Spinal Part of Accessory Nerve:**

1. Special visceral efferent for sternocleidomastoid and trapezius.
2. General somatic afferent—spinal nucleus of 5th cranial nerve. It receives proprioceptive impulses from the above two muscles.

**11th Cranial Nerve: Hypoglossal—12th Cranial Nerve:**

1. General somatic efferent for all intrinsic muscle of tongue and three extrinsic muscles – styloglossus, genioglossus and hyoglossus (and not the palatoglossus).
2. General somatic afferent – spinal nucleus of the 5th cranial nerve. It receives proprioceptive impulses from the muscles of tongue.

# BRAIN

Brain is the part of the central nervous system situated in the cranium. Weight of the brain is around 1300 gm. It is soft and is surrounded by the cerebrospinal fluid which protects it from minor shocks. Brain is well protected by the bony rigid cranium. The meninges cover the brain and are arranged from inside out as the pia-arachnoid and the dura (PAD). Piamater is the thin vascular layer which follows the surface of the brain and dips into sulci. Outside the piamater is the arachnoid mater which jumps from surface of one gyrus to the other. It creates the space between the pia and the arachnoid known as the subarachnoid space. It contains blood vessels which supply the brain. The vessels which supply the brain are surrounded by the cerebrospinal fluid.

**Cistern:** Larger subarachnoid space is known as the cistern. They are:
1. Basilar : at the base of the cerebrum.
2. Pontine: infront of the pons.
3. Medullary infront of the medulla and the
4. Cerebellomedulary between the medulla and the cerebellum.

**Cranial Compartments:** The cranial cavity is divided into two compartments the supratentorial above the tentorium cerebelli and the infratentorial below.

**Clinical:** If the intracranial tension in the supratentorial compartment increases it causes herniation of the temporal bone through the tentorium. When the intracranial tension in the infratentorial compartment increases it causes herniation of the tonsils through the foramen magnum pressing the medulla causing death.

**Parts of the Brain:** Embryologically brains is divided into the forebrain, midbrain and the hindbrain. Forebrain is divided into the telencephalon, i.e. cerebrum and the diencephalon which includes the thalamus, hypothalamus, metathalamus, epithalamus and the subthalamus.

**Mesencephalon:** Mesencephalon constitutes the midbrain which lies in the hitus of the tentorium cerebelli.

**Rhombencephalon:** It consists of pons, medulla and the cerebellum.

**Cavities of the Brain:** Brain is not a solid structure. It has cavities lined by the fine layer of epithelium known as the ependyma. The tuft of blood vessels covered by the ependyma is known as the choroid plexus. The choroid plexus produces CSF which circulates through the ventricular cavity and enters the subarachnoid space.

CSF from the subarachnoid space is pushed into the superior sagittal sinus through the arachnoid granulations.

**Arachnoid Granulations:** Arachnoid granulations are the macroscopic projections of the arachnoid mater into the superior sagittal sinus, which pushs CSF into the venous circulation. Arachnoid granulations are present by the side of the superior sagittal sinus more posteriorly than anteriorly. They increase in size with the age and get calcified.

The impressions produced by the arachnoid granulations can be seen by the side of the groove meant for the superior sagittal sinus.

**Cavity of the Telencephalon:** Two lateral ventricles.

**Cavity of the Diencephalons:** The third ventricle – the cavity between the two thalami.

**Midbrain:** Aqueduct of Sylvius.

**Hindbrain:** Fourth ventricle.

The cavity of the hindbrain is known as the fourth ventricle and is bounded infront by the pons and medulla and behind by the cerebellum.

Both the lateral ventricles and the third ventricle communicate with each other through the foramen of Monro. Third ventricle communicates with the fourth ventricle below through the aqueduct of Sylvius.

Roof of the fourth ventricle in its lower part presents a foramen known as foramen of Magendie while at lateral angles of the fourth ventricle are the paired foramina of Luschka. CSF escapes through the foramina of the 4th ventricle and enters the subarachnoid space. In the space the CSF rolls over the superolateral surface of the cerebrum and enters the superior sagittal sinus through the arachnoid granulations.

**Intracranial Venous Sinuses:** Intracranial venous sinuses are the intracranial venous channels situated in the cranium between two layers of the dura lined by epithelium. They do not have muscular walls or the valves granting them immunity from compression.

Grey mater of the cerebrum and the cerebellum are placed outside and is known as the cortex. In the brain the grey mater is out and the white mater is in. The arrangement of the white and the grey is reverse in the spinal cord. Brainstem has the same arrangement as that of the spinal cord, where the white mater forms the outer surface and grey mater forms the inner core.

**Inferior Surface of the Cerebral Hemisphere (Figure 309):** Inferior surface of the cerebral hemisphere is also known as the base of brain. It is bounded by optic chiasma anteriorly, optic tract anterolaterally and the cerebral puduncles posteriorly. It contains tuber-cinerium, infundibulum of the pituitary, mammilary bodies and the posterior perforated substance. Lateral to the optic chisma is the space known as valeculla. It is bounded above by the anterior perforated substance. Internal carotid artery divides in the valeculla into anterior and the middle cerebral arteries.

Anterior perforated substance is pierced by anterolateral group of central branches of the circle of Willis.

**Brainstem:** Brainstem consists of midbrain, pons and the medulla from above downwards. Midbrain occupies the tentorial hiatus, while the pons and the medulla lie on the clivus anteriorly in the infratentorial compartment of the cranium.

Brainstem contains vital centres like cardiovascular, respiratory and the reticular formation. They are packed in the medulla with the cranial nerve nuclei and ascending and the descending tracts.

The distribution of the cranial nerve nuclei in the brainstem.

Midbrain contains third and fourth cranial nerve nuclei. Pons contains nuclei of 5, 6, 7, 8 cranial nerves. Medulla oblongata cntains 9, 10, 11, 12 cranial nerve nuclei. Third nerve leaves the midbrain anterior-medial to the crus cerebri. Fourth nerve leaves the midbrain below the 3rd on the dorsal aspect of the midbrain. 7 and 8 nerves escape from the pons laterally. The 6th nerve appears on the ventral aspect of the brainstem below the lower border of the pons and above the base of the pyramid. 9th, 10th, 11th cranial nerves leave medulla in the groove between the olivary nucleus and the inferior cerebral peduncle. The rootlets of the hypoglossal nerve

leave the ventral aspect of the medulla between the pyramid medially and the olive laterally. It is crossed by the vertebral artery from the front.

All the three constituents of the brainstem are connected to the cerebellum through three cerebral peduncles. Midbrain through the superior pons through the middle and the medulla through the inferior cerebellar peduncles respectively. Inferior cerebellar peduncle is also known as the restiform body.

# MEDULLA

Medulla has two parts the upper open part where it forms the floor of the fourth ventricle presenting the hypoglossal and the vagal triangles. Closed part of the medulla has an extension of the spinal central canal. On the dorsal surface of the medulla are the elevations produced by the nucleus gracilis and the cuneatus. The nucleus cuneatus is placed laterally. Lateral to the nucleus of cuneatus is the spinal nucleus and the tract of trigeminal nerve. The corticospinal tracts are seen crossing the midline infront of central canal. The tract cuts the ventral part of the anterior grey mater.

At times the tuberculus cenerium is present on the lateral aspect of the nucleus cuneatus. It represents the spinal tract of the trigeminal. It is important to remember that in trigeminal neuralgia this tract can be approached easily.

Grey mater detached by the pyramidal tract is divided into two the supraspinous and the accessory nuclei. Supraspinous nuclei are continuous with the nucleus of the 12th nerve. The accessory nuclei is continuous with the nucleus ambigus above and the nucleus of the accessory nerve below.

Closed part of the medulla ventrally shows median sulcus, elevation of the pyramid, anterolateral sulcus, elevation of the olive and lateral to it is the posterolateral sulcus. Beyond the posterolateral sulcus is the inferior cerebellar peduncle.

# INTERNAL STRUCTURE OF THE MEDULLA

Internal structure of the medulla is studied with the help of three horizontal sections taken at:

1. Pyramidal decussation
2. Sensory decussation
3. Mid-olivary decussation

## At the Level of Pyramidal Decussation

**Grey Matter:**

1. Nucleus gracilis
2. Nucleus cuneatus
3. Nucleus of the spinal tract of the trigeminal.
4. Cut-off part of the anterior grey mater.

The cut-off part of the anterior grey mater is divided into the medial as the first cervical nucleus and the lateral as the spinal nucleus of the accessory nerve. Supra-spinus and the accessory nuclei. Supra-spinus part continues with the nucleus of the hypoglossal nerve above and the first cervical segment below (Figures 307 and 308).

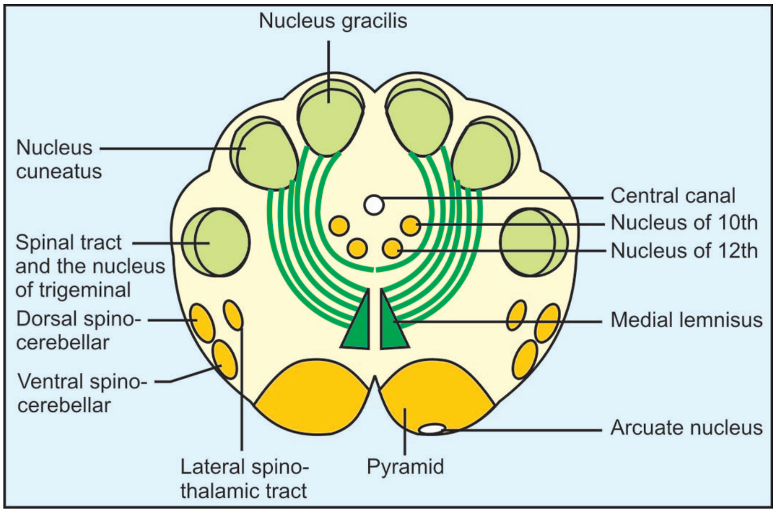



**Figure 307** Showing medulla at sensory decussation

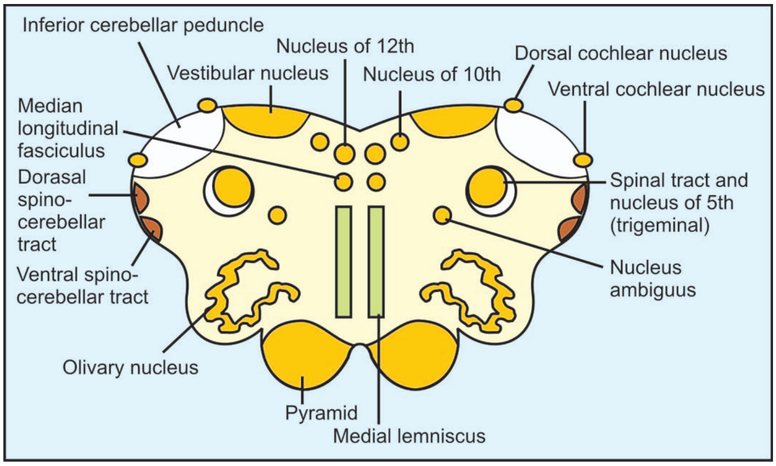



**Figure 308** Showing section passing through the superior half of medulla

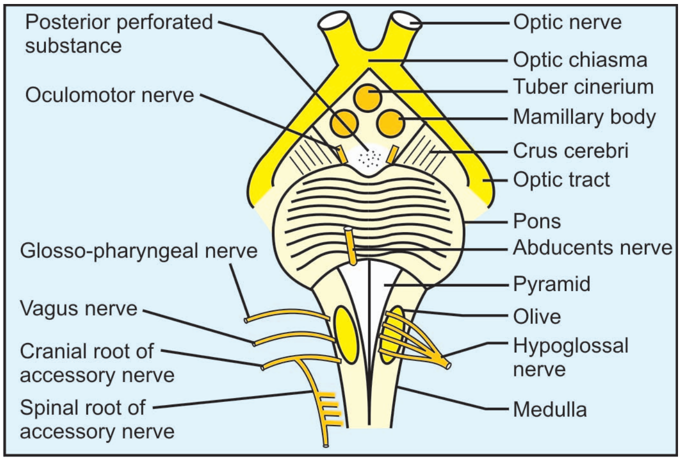



**Figure 308A** Showing anterior view of the brainstem inter-peduncular fossa

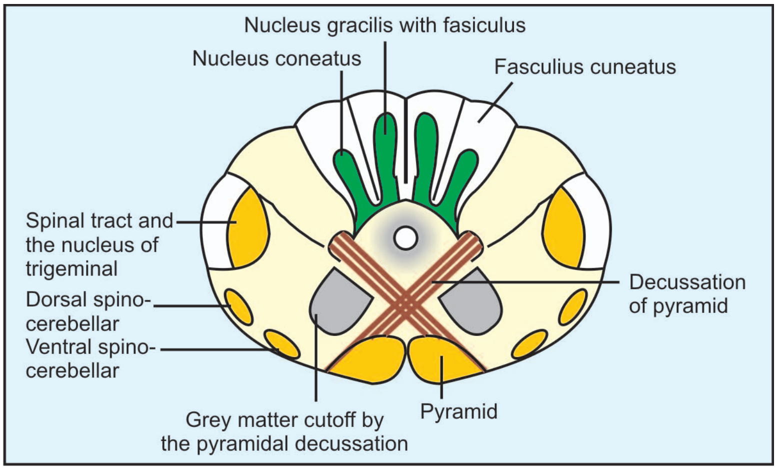



**Figure 308B** Showing cross-section of medulla at the pyramidal decussation

**White Matter**:
1. Pyramidal decussation – the fibres go to the lateral white column and run downwards as the corticospinal tract.
2. Fasciculi of the gracilis and cuneatus.

Lateral part contains ascending and descending tracts.

## At the Level of Sensory Decussation

**Grey Matter**: Nucleus of gracilis and cuneatus, accessory cuneat nucleus, nucleus of the spinal tract of trigeminal, inferior olivary nucleus, nucleus of 10th , 12th and nucleus of the tractus solitarius are seen.

**White Matter:** Nucleus gracilis cuneatus give rise to internal arcuate fibres forming medial leminiscus which carries conscious proprioception, discriminative touch, and vibration, are seen in the middle ventral to the central canal.

Pyramid is close to the midline, spinal tract of the trigeminal lateral tuberculus cenerium lateral to the nucleus cuneatus can be seen. Corticospinal tract is not seen as it forms the pyramid.

## Section of the Medulla at the Mid-olive

**Grey Matter**: Olivary nucleus, hypoglossal nucleus and nucleus ambiguus are in the reticular formation. Nucleus ambiguus sends branchial efferent fibres to the ninth, tenth and cranial root of the accessory nerve.

**White Matter**: Medial lemniscus, pyramidal tract, spinothalamic tract anterior and posterior spino-cerebellar tracts and the spinal tract of the trigeminal are seen.

**Blood Supply**: Anterior spinal artery supplies the area of 12th nerve, medial lemniscus and the pyramidal tract.

## Posterior Inferior Cerebellar Artery (PICA)

Supplies the posterolateral region of the medulla. Nucleus gracilis and the cuneatus receive blood supply from the posterior spinal arteries. The nucleus ambiguus, tractus solitarius, vestibular, cochlear nuclei, spino-thalamic and the descending sympathetic fibres are supplied by posterior inferior cerebellar artery (PICA). Destruction of these leads to posterior inferior cerebellar artery syndrome along with Hornor syndrome.

Anterior surface of the medulla is supplied by vertebral arteries.

Cochlear nucleus receives fibres from the cochlear nerve. They cross and form the trapezoid body. Lateral leminiscus is formed by the ascending fibres of the superior olivary nucleus. Para-abducent nucleus is the part of the abducent whose fibres cross to opposite side, join the medial longitudinal faciculus with the part of the third nerve. It is responsible for coordinating the lateral rectus of one eye and the medial rectus of the other. It is the horizontal gaze which is controlled by the paramedian pontine reticular formation. (PPRF).

**Blood supply of Pons**: Anteior surface of pons is supplied by the basilar, superior cerebellar, anterior inferior cerebellar and the labirinthyne arteries.

**Cerebellopontine Angle**: It is bounded laterally by the pons, cerebellum and the superior border of the petrous part of the temporal bone. Acoustic neuroma of the cerebello-pontine angle compresses the 8th nerve and the 7th nerve along with the pons. It leads to deafness, vertigo and tinnitus. Patient develops facial palsy and ataxia.

# PONS

It is divided into the basilar and the tegmetal parts. Basilar part contains fibres such as cortico-spinal, cortico-bulbar, cortico-pontine, cortico-cerebellar. Vestibular nuclei are divided into four groups, superior, inferior, middle and the lateral.

Cochlear nuclei divided into dorsal and ventral. It has following efferent connections:

1. To the flocculonodular lobe.
2. To the medial longitudinal faciculus which inervates the muscles of the eyeball. Co-ordination of eye, head and the neck movements occur according to the position of the body.
3. Vestibulo-spinal tract reaches the motor neurone of the spinal cord.

**Cochlear Nucleus**: It receives the fibres of the cochlear nerve. They cross to the opposite side and form the trapezoid body. Lateral leminiscus is formed by the ascending fibres of the superior olivary nucleus and the nucleus of the trapezoid body. Paraabducent is the part of the abducent whose fibres cross to the opposite side and joins the medial longitudinal fasciculus to the part of the third nerve. It is responsible for co-ordination of lateral rectus of one eye and the medial rectus of the other. It is the horizontal gaze. It is controlled by paramedian pontine reticular formation which controls the horizontal gaze. Superior salivary nucleus lies above the ponto-medullary junction. Parasympathetic fibres from it joins the facial and form nervous intermedius which supplies the lacrimal, submandibular and the sublingual glands. Ventral trigeminal thalamic tract crosses and continues as the trigeminal lemniscus.

The center for the lateral gaze movement is placed in the pons.

**Millard Gublar Syndrome**: Millard Gublar syndrome is also known as medial pontine syndrome. The lesion is in the basilar part of the pons. In this syndrome there is contralateral hemiplegia with intra-pontine damage to the 6th and the 7th nerve. The 6th and the 7th nerve lesion are of the lower motor neuron type.

**Weber's Syndrome**: There is contralateral hemiplegia and ipsilateral third nerve paralysis.

**Clinical:**

| *Name* | *Medial medullary syndrome* | *Lateral medullary syndrome* |
|---|---|---|
| Arteries involved | Anterior spinal artery the branch of the vertebral | Posterior inferior cerebellar artery the branch of the vertebral. Gracilis and the cuneate tubercles are supplied by the posterior spinal arteries |
| Region affected | Hypoglossal nucleus, pyramid and the medial lemniscus | Nucleus ambiguus, Nucleus of the tractus solitarious, Vestibular nucleus. Spinal nucleus and the tract of the trigeminal. Spinothalamic tract, inferior cerebellar peduncle and the descending sympathetic fibres. |
| Result | Contralateral hemiplegia<br>Epsilateral paralysis of the 12th affecting the tongue.<br>Loss of conscious<br>Propriosensation<br>Vibration and<br>Two point discrimination. | Dysarthria, Dysphagea,<br>Loss of taste sensation, loss of pain and temperature on the opposite half of the body. Loss of temperature and pain of face on the same side. Ataxia, vertigo, nausea, nystagmus, Horner's syndrome and shifting of the uvulae to the opposite side. |

# MIDBRAIN

It is the highest part of the brainstem. Study of the midbrain is done by studying the sections at the level of superior corpora quadrigemina and the inferior corpora quadrigemina.

## Section at the Superior Corpora Quadrigemina

Cerebral peduncles are infront and oculomotor nerve appears in the intrapeduncular fossa medial to the crus. Posterior cerebral and superior cerebellar arteries form the anterior relations of the crus. It must be remembered the 3rd and the 4th cranial nerves pass through the posterior cerebral and the superior cerebellar arteries. The trochlear nerve is lateral to the crus and the oculomotor is medial to the crus. Optic tract is related to the crus antero-posterior. Trochlear nerve which emerges from the dorsal aspect of the midbrain after crossing to the opposite side runs lateral to the crus and it passes between the posterior cerebral and the superior cerebellar arteries. Posterior perforated substance is placed in an angle between the crura anteriorly **(Figures 309 and 310).**

**Figure 309** Showing transverse section of midbrain at the level of superior colliculus

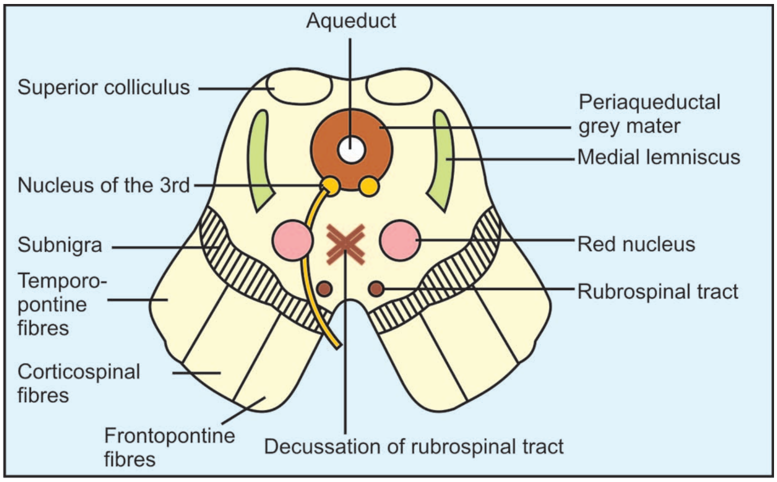
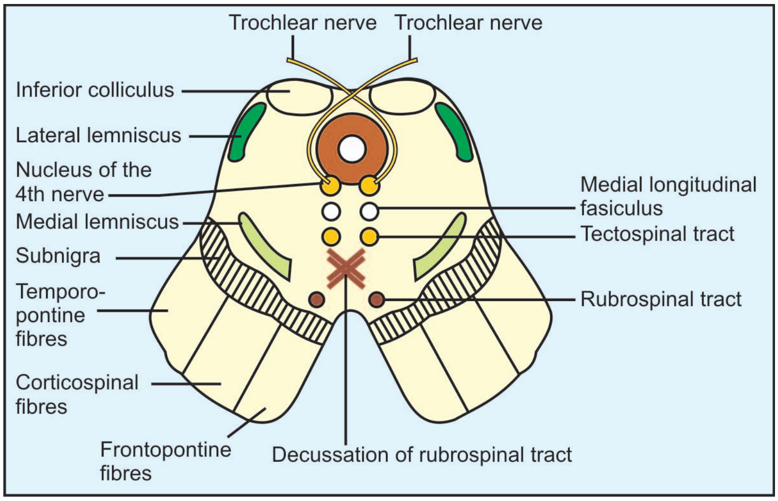



**Figure 310** Showing transverse section of midbrain at the level of inferior colliculus



Dorsal surface of the midbrain presents four elevations two upper and the two lower, upper pair is known as superior corpora quadrigemina and the lower one is known as inferior corpora quadrigemina. A cross like sulcus lies on the dorsum of the midbrain in the midline. Vertical limb of the sulcus runs downwards and continues with the superior medullary velum.

Superior brachium connects the superior collicus to lateral geniculate body and the inferior brachium connects the inferior colliculus to the medial geniculate body.

Substantia nigra separates the crus from the tegmentum. It has pigmented cells hence it looks black. It is made-up of compact and the reticular layers. Reticular part is anterior to the compact part and receives the strio-nigral fibres from the caudate nucleus and putamen. It also receives fibres from the globus pallidus.

**Cortex:** Fibres from the cortex go to the reticular part of the substantial nigra and the red nucleus. Fibres from the substantial nigra go to the caudate and putamen. This is known as the nigrostriate path. They are dopaminergic fibres and forms dopamine. Nigrostriate fibres act as the break of the corpus striatum and control the voluntary movements. They are the constituents of extrapyramidle systems. Degeneration of the black looking neurons in the substantia nigra leads to Parkinson's tremors. Due to deficiency of the dopamine in the corpous striatum, patient has intentional tremours and mask like face. He is unable to stop and may dash against the wall or may go out straight through the door if he meets one. The patient of parkinsonism can be benefited by the drug known as levo-dopa. Levo-dopa goes to the nigrostriat system increasing the concentration of the drug.

Section at the level of inferior coliculi.

1. Shows reticular formation
2. Nucleus of the fourth nerve lies ventrilateral to the aqueduct.
3. Mesencephalic nucleus of the fifth lies lateral to the aqueduct. It has pseudo-unipolar cells.

Mesencephalic nucleus of the 5th is the only part of the nervous system which develops from the neural crest. The peripheral processes of the pseudo-unipolar cells of mesencephalic nucleus of the fifth bring peripheral sensations from muscles of mastication, eyeball and the tongue. The nucleus is involved in eliciting masseteric or jaw reflex. Patient is asked to open the mouth and examiner taps the chin. It produces sudden contraction of masseter and the temporalis muscles. White matter is formed by the decussession of the fibres of superior cerebellar peduncles. The crossed ascending fibres go to red nucleus and the ventro-postero-lateral nucleus of the thalamus of the opposite side. Rubro-spinal tract is infront and the tectospinal tract is behind. Oculomotor nucleus comprises of various nuclear components they are as under:

a. central,
b. caudal central
c. ventri-medial and
d. dorsi-lateral and
e. ***Edinger-Westphal nucleus:*** It is parasympathetic to the sphincter pupillae and the ciliary muscles. Mesencephalic nucleus of the fifth lies in the lateral part of the peri-aqueductal grey mater, Pretactal nucleus is in close relation with the superior colliculus which initiates the pupillary light reflex and is mediated through the pretectal nucleus.

**Red Nucleus:** Red nucleus lies in the tegmentum of the midbrain lying behind the substantia nigra at the level of superior collicus. It has connections to the cerebellum through the superior cerebral peduncle with dentate, emboliformis and globosus nuclei. The connecting tract is known as rubro-cerebello tract. It is connected to the ventro-lateral nucleus of the thalamus through rubro-thalamic tract. In addition to this it is also connected with the reticular formation, cranial nerve nuclei and the inferior olivary nucleus. The red nucleus is the relay centre on the cerebello-rubro spinal, cortico-rubro spinal and the cortico-rubral reticular tracts. White matter in the extrapyramidal system and plays important role in maintaining the tone of the voluntary muscles. The dorsal decussation of the white matter is formed by the superior cerebellar peduncles. The medial longitudinal fasciculus is closely related to the oculomotor complex. The ascending tracts consists of medial lemniscus, trigeminal lemniscus and the spinal lemniscus.

**Medial Longitudinal Fasciculus (MLF):** Medial longitudinal fasciculus is made of group of fibers in the form of bundle and lies in the mid-line, it retains its medial position throughout the brainstem. Superiorly it ascends to the rostral interstitial nucleus of MLF. This nucleus is in association with interstitial nucleus of Cajal and Darkshewitsch. It forms the premotor centre for vertical gaze of the eyes. It is done through the connections with nuclei of third and fourth cranial nerves. Inferiorly the MLF becomes continuous with anterior intersegmental tract of spinal cord.

The MLF receives a large contribution from the vestibular nuclei. By virtue of the fact, that its connection with the vestibular nuclei, it has automatic connections with the 3rd 4th 6th and the spinal accessory in addition to the nucleus of lateral lemniscus. It establishes connections with anterior horn cells of cervical spinal cord through fasciculus proprius. It also carries the axons of para-abducent nucleus to the contralateral oculomotor nucleus (As a result controlling the action of medial rectus muscle). It has connections with pontine paramedian reticular formation (PPRF), which is the horizontal gaze centre in the pons. The rostral interstitial nuclei of MLF and the MLF of the two sides are connected by the posterior commissure. The MLF plays an role in co-ordination of vertical and horizontal conjugate movements of the eyes. It also plays an important role in co-ordinating the movements of eyes and head in response to vestibulocochlear stimuli.

**Lesions of Medial Longitudinal Fasciculus:** Unilateral damage to the MLF in the midbrain and pons leads to inter-nuclear ophthalmoplegia. When patient looks to the lateral side it causes nystagmus. Internuclear ophthalmoplegia results due to unilateral damage to MLF in midbrain or pons. This interrupts the path of impulses from the horizontal gaze centre in the pons to the oculomotor nucleus in the midbrain. On an attempted lateral gaze, there is nystagmus (jerky movements) in the abducting eye (contralateral eye) and slow or absent adduction on the affected side. Lesion in the PPRF and MLF on the same side will result in one and half syndrome, in which there is failure of lateral conjugate gaze on the side of lesion together with impairment of adduction and nystagmus on abduction in the opposite eye. In this lesion the eye on the side of the lesion has totally lost the capacity of horizontal movement and the eye on the opposite side eye can move horizontally only on abduction.

**Lesion of the Vertical Gaze Centre:** This gives rise to defects in the up-gaze or down-gaze or both. Lesion of posterior commissure and its nuclei cause disturbances of up-gaze. The lesion of interstitial nucleus of Cajal may cause paralysis of downward gaze.

**Tectum:**

i. The inferior colliculi are a pair of ovoid masses of grey mater forming the lower part of tectum. Each inferior colliculus is a relay centre in the auditory pathway. The inferior colliculi of two sides are reciprocally connected to each other. The inferior colliculus receives the auditory impulses from both ears through the lateral lemniscus and the fibres from the ipsilateral medial geniculate body via the inferior brachium. It projects on the medial geniculate body through the inferior brachium. Some connections are believed to exist with the superior olivary nucleus and cochlear nuclei. The inferior colliculi are the reflex centres for responses to auditory stimuli. They are important in locating the source of sound.

ii. The superior colliculi are a pair of ovoid masses of grey mater located above the inferior colliculi. Each superior colliculus is connected to the lateral geniculate body of its side by superior brachium. It receives retinotectal fibres, which travel in the optic tract, reach the lateral geniculate body from where it travels in the superior brachium for termination in the superior colliculus. It also receives the spinotectal fibres from the spinal cord and the corticotectal fibers from occipital and temporal lobes. Its efferent connections are as follows. The tectospinal fibres cross-over in the dorsal tegmental decussation in the midbrain and reach the grey matter of the opposite side in the spinal cord. The tectothalamic fibres end in the pulvinar of thalamus and the tectocortical fibers reach the occipital cortex. The superior colliculi are the reflex centers for the movements of the eyes and the head in response to the visual stimuli. With multiple connections it is possible that the superior colliculi play an integrating role between the visual inputs and various activities of the body.

**Arterial Supply**: The midbrain is supplied by the following arteries:

1. Posterior cerebral.
2. Superior cerebellar
3. Basilar
4. Posterior communicating.

Arteries get divided into two groups the paramedian and the circumferential arteries. The circumferential artery supplying the tectus is known as quadrigeminal artery.

## Clinical

**Weber's Syndrome:** Weber's syndrome results due to infarction in basal region of cerebral peduncle due to blockage of a branch of posterior cerebral artery. This causes contralateral hemiplegia and ipsilateral paralysis of muscles supplied by third nerve.

**Benedikt's Syndrome:** Benedikt's syndrome results due to lesion of the tegmentum involving the red nucleus, fibers of the third nerve and the medial lemniscus. This syndrome includes ipsilateral paralysis of the muscles supplied by third nerve, contralateral hemianesthesia, i.e.loss of proprioception, discriminative touch and the sense of vibrations with involuntary

movements which are known as choreo-athetoid movements on the side of lesion.

**Perinaud's Syndrome:** Perinaud's syndrome is caused by the compression of the dorsal region of the midbrain which includes the superior colliculi. It results due to pineal gland tumour or vascular malformation. It leads to impaired vertical gaze i.e. abnormal pupill or loss of accommodation reflex. Compression of the aqueduct of silvius can lead to hydrocephalus.

**Compression of the Midbrain:** In extradural hematoma of the right side there increased supratentorial, intracranial pressure. As a result of this the uncus of the right side herniates through the tentorial hiatus pushing the midbrain to the left. The midbrain of the left pushes against the edge of the tentorial hiatus. It causes dilated and fixed pupil on the right side and the epsilateral hemiplagia. In other words the herniation of the uncus through the tentorial hiatus causes ipsilateral pupillary changes and the ipsilateral paraplegia. This is known as effect of Kernohan's notch. It is also known as Kernohan's sign.

# CEREBELLUM

Cerebellum is the head ganglion of balance equilibrium and the posture. It is responsible for co-ordination of the voluntary movements of the body. Cerebral cortex initiates the movements and the cerebellum regulates them. It is situated in the posterior cranial fossa under the tentorium cerebelli. Outer surface of the cerebellum has grey matter known as cerebellar cortex. Inside the cerebellum are the nuclei, i.e. dentatus, emboliformis, globosus and fastigii. White matter of the core of the cerebellum is arranged typically like the branching of a tree. (Arbor vetia cerebelli). Cerebellum is anatomically and functionally connected to the brainstem by means of the superior middle and the inferior cerebellar peduncles. Cerebellum is the part of the hindbrain enclosing the fourth ventricle between the pons and medulla infront and the cerebellum behind.

*Weight of the cerebellum: 150 gm*

**Parts of the Cerebellum (Figures 311 A to C):,** Cerebellum has three lobes anterior, middle and the posterior. They are demarcated by the postero-inferior, lateral and the primary fissures. Horizonal fissure demarcates the superior surface of the cerebellum from the inferior. Fissura prima divides the anterior lobe from the middle and it is seen on the superior surface.

Anterior lobe includes lingula, culmen and the central lobule. Posterior lobe includes declive and uvulae, Floculo-nodular lobe includes nodule. These are the parts of the vermis.

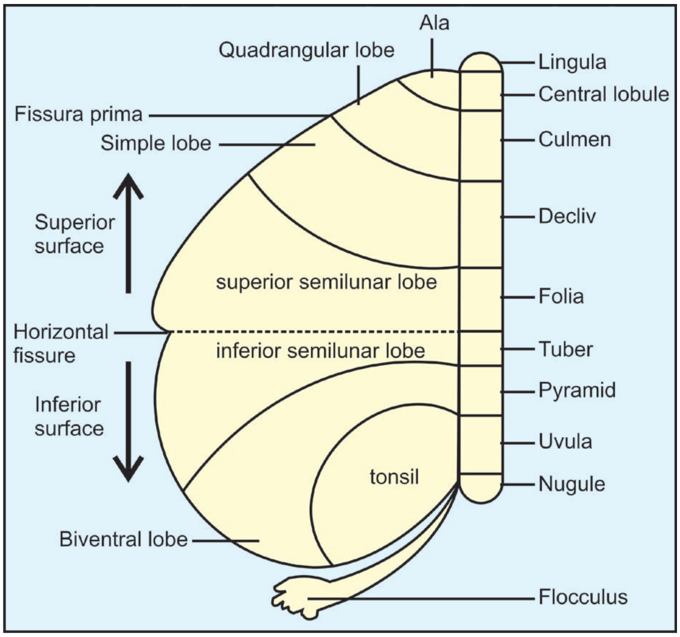



**Figure 311A** Showing cerebellar lobe and the vermis

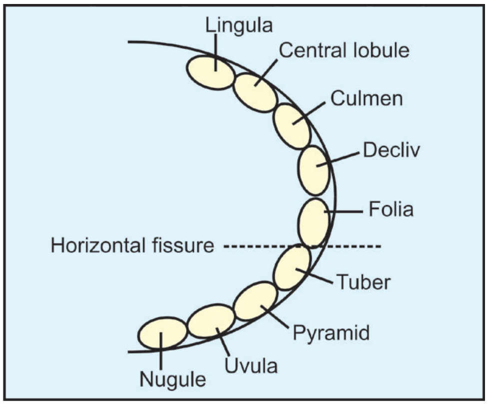



**Figure 311B** Showing part of the superior and inferior vermis

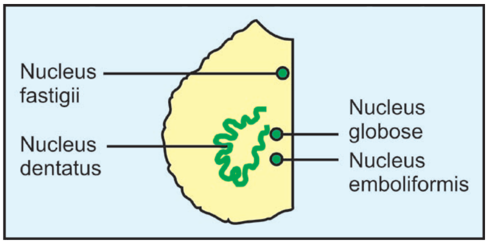



**Figure 311C** Showing nuclei of cerebellum

The division of lobes includes following parts of the cerebellum.

**Anterior**—Central lobule (ala) Qudraingular lobe.

**Posterior**—lobular simplex superior and inferior semilunar lobules.

**Flocculo-nodular**—the flocculus.

**Vermis:** The cerebellum has the superior vermis and the inferior vermis. The superior vermis is in the midline of the superior surface and is seen as the midline elevation. On the other hand the inferior vermis is seen in the midline in the depression. Posterior lobe of the cerebellum includes the tonsils which lie at the edge of the foramen magnum and normally never ever pass through the foramen magnum.

The parts of the vermis as under:

1. Nodule:
2. Uvula
3. Pyramid
4. Tuber
5. Folia
6. Declive
7. Culmen
8. Central lobule and
9. The lingula

They are arranged from below upwards in the sequence given above.

**Functional Lobes of the Cerebellum:**

1 ***Archi-cerebellum:*** It includes old floculo-nodular lobe and lingula. It has mainly the vestibular connections. It is for the equilibrium, balance and the locomotion.

2. Paleo-cerebellum which developes later includes anterior lobe, pyramid and the uvula without the lingula. It controls the muscle tone and contraction and is responsible for the crude movements of the limbs. Its connections are mainly spinocerebellar.

3. Neocerebellum includes middle lobe without pyramid and the uvulae. It regulates the movements of the body.

**Afferent and Efferent Connections of the Cerebellum:** Following are the afferent connection of the inferior cerebellar peduncle:

1. Trigeminocerebellar
2. Posterior spinocerebellar

3. Parolivo-cerebellar
4. Vestibulo-cerebellar
5. Reticulo-cerebellar
6. Olivo-cerebellar

Following are the efferent connection which pass through the inferior cerebellar peduncle.

1. Cerebello spinal
2. Cerebello nuclear
3. Cerebello olivary
4. Cerebello vestibular
5. Cerebello reticular

**Middle Cerebellar Peduncle:** It contains fibres from pons to the cerebellum of the opposite side. They include pontocerebellar, cerebellar pontine, corticopontine.

**Superior Cerebellar Peduncle:** *Afferent*

1. Anterior spinocerebellar
2. Tactocerebellar
3. Trigeminocerebellar.

*Efferent*

1. Dentatothalamic
2. Dentatorubral both crossed and uncrossed. They go from dentate, emboliformis and the globosus nuclei of the cerebellum.

**Blood Supply:** Superior surface of the cerebellum is supplied by a branch of the basilar artery, i.e. superior cerebellar artery, inferior surface is supplied by two arteries, the antero-inferior part of the cerebellum is supplied by the anterior cerebellar artery. The postero-inferior surface of the cerebellum is supplied by the posterior inferior cerebellar artery which is a branch of the vertebral.

**Clinical:**

1. *Cerebellar syndrome:* There is hypotonea on the side of the lesion. Intentional tremors, dysmetria, i.e. over shooting the index when attempted to touch the tip of the nose.
2. *Adiodokinasia*, i.e. unable to perform pronation and supination rapidly.
3. *Dysarthria*, i.e. difficulty in speech.
4. *Dismetria:* Defective conjugate movement of the eyes, i.e. nystagmus

Swinging on the side of lesion

Falling down on the side of lesion when the eyes are closed (Rhomberg's sign).

**Meduleo-blastoma:** Granular cell tumor of the vermis is known as the meduleo-blastoma. When it enchroaches the cerebellopontine angle, the 7th and the 8th cranial nerves are compressed. It produces pressure on the 4th ventricle. When the tumor grows rapidly the pressure in the infratentorial compartment is raised, leading to the herniation of the tonsils through the foramen magnum.

**Arnold-Chiari Malformations:** In this condition the herniation of the tonsil causes obstruction to the flow of the CSF and may cause hydrocephalus in early infancy.

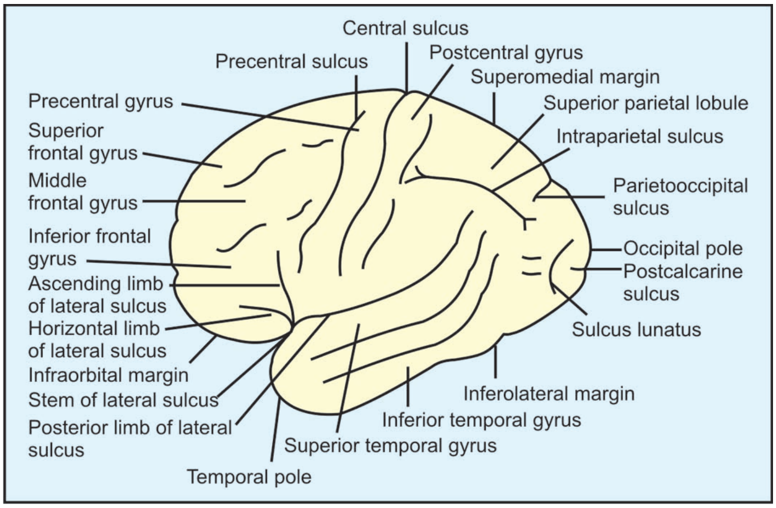
# SUPEROLATERAL SURFACE OF THE CEREBRAL HEMISPHERE

It is ovoid in shape and presents three poles, three borders and three sulci. The borders are supero-medial, infero-lateral and the orbital. The poles are the frontal, temporal and the occipital. As regard the sulci it has the central sulcus, posterior ramus of the lateral sulcus and the parieto-occipital sulcus. Supero-lateral surface of the hemisphere is divided into the four lobes namely the frontal, temporal, parietal and the occipital.

**Frontal Lobe (Figures 312, 313 and 313 A):**

Frontal lobe is limited above by the supero-medial margin, below by the posterior ramus of the lateral sulcus and behind by the central sulcus. Infront of the central sulcus there is pre-central gyrus which is the motor area having pyramidal cells of Betz, axons of which continue as the cortico-spinal tract. Over the motor area 4 body is represented upside down, i.e. the head below and the feet and the perineum above. Infront of the pre-motor gyrus is the area 6, which is concerned with the skill achieved by repeated practice. Rest of the frontal lobe is divided into three gyri. The superior, middle and the inferior. Posterior part of the middle frontal gyrus is labelled as the area 8, which is meant for the conjugate deviation of the eyes. Infront of the area eight, the frontal lobe present 9, 10 and 11 area, which constitute the pre-frontal cortex. It is responsible for behaviour and personality. In the inferior frontal gyrus there is an area placed between the horizontal and the ascending rami of the lateral sulcus known as the Broca's motor speech area (area 44, 45).

**Figure 312** Showing sulci and gyri on superolateral surface of the cerebrum



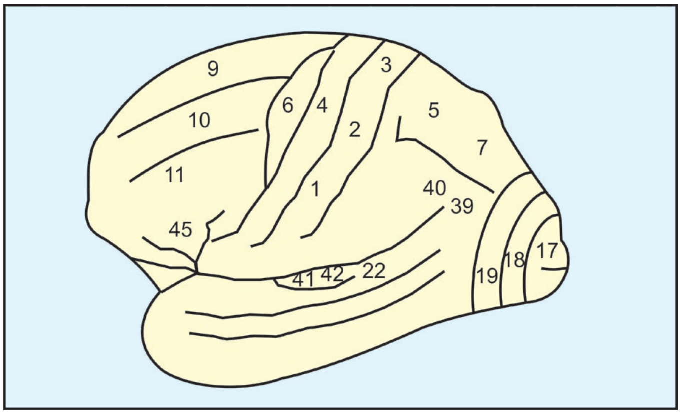



**Figure 313** Showing supero-lateral surface with important cortical area

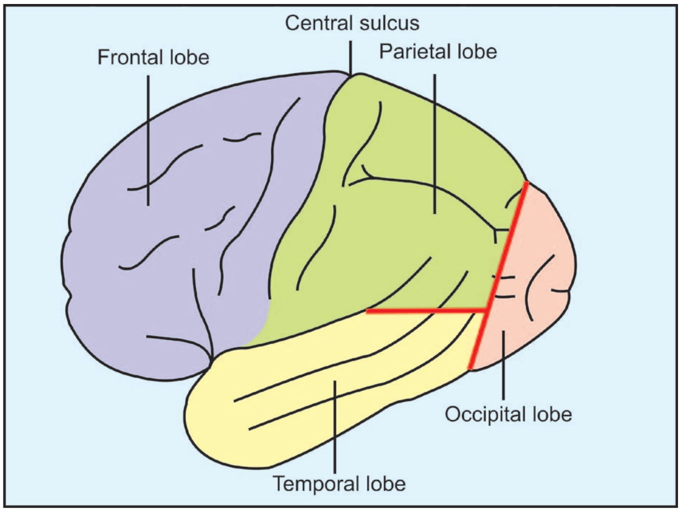



**Figure 313A** Showing lobes of cerebrum as seen on the supero-lateral surface

**Parietal Lobe:** Parietal lobe is bounded infront by the central sulcus behind by an imaginary line joining the parieto-occipito sulcus and the pre-occipital notch. It is worth remembering that the parieto-occipito sulcus is situated 5 cm anteriorly on the supero-medial margin while the pre-occipital notch is situated 5 cm infront of the occipital pole on the infero-lateral margin. The line joining the parieto-occipital sulcus and the pre-occipital notch separates the occipital lobe from the rest of the brain.

The parietal and the temporal lobes are separated by an imaginary line extending posteriorly from the posterior ramus of the lateral sulcus to the line connecting the parieto-occipital sulcus and the pre-occipital notch. Postcentral sulcus lies behind the central sulcus. Postcentral gyrus lies behind the central sulcus. The postcentral gyrus is labelled as 3, 1, 2 from above downwards. It is the sensory area receiving information from the opposite half of the body. Body is represented upside down. Rest of the parietal lobe is divided into the superior and the inferior parietal lobules by the intra-parietal sulcus. Above the intra-parietal sulcus are the areas 5 and 7. While the infra-parietal lobules has the area 40 and 39. Area 40 is for steriognosis, i.e. identifying the objects by feeling when the eyes are closed. While the area 39 is for word blindness. Area 41 and 42 occupy the superior temporal gyrus as an auditory area. While the rest of the superior – temporal gyrus is marked as the area 22. The temporal lobe is divided into three the superior, medial and the lower with the help of superior and inferior temporal sulci into three gyri by two sulci. In the occipital lobe the

apex of the occipital pole is cut by the post-calcaline sulcus which is arched by the sulcus lunatus. Within the sulcus lunatus is the visual area. In the sulcus is the parastriate area and outside is the peristriate area.

**Insula:** Insula is the pyramidal mass of grey mater lying in the stem of the lateral sulcus. It is not seen on the surface as it is covered with operculi, i.e. frontal, parietal and the temporal. It is surrounded by a circular sulcus at the base. While its apex is connected to the anterior perforated substance by means of limen insuli.

Surface of the insula has long and short gyri. After cutting the opercula the coronal section of the cerebrum at the site of insular provides an insight for the internal important structures hidden within the cerebrum. Medial to the insular cortex the following structures are seen from the superficial to the deep.

1. Claustrum
2. External capsule
3. Lentiform nucleus
4. Internal capsule.

Followed by caudate nucleus and the thalamus.

**Blood Supply of Insula:** It is supplied by the middle cerebral artery.

**Blood Supply of the Superolateral Surface of the Cerebral Hemisphere:** The middle part above and below the posterior ramus of the lateral sulcus is supplied by the middle cerebral artery and the part infront and above is supplied by the anterior cerebral artery. The part lying below and posterior is supplied by the posterior cerebral artery.

*Note:* The Brocha's area is situated on the left side in the right handed person.

**Cortical Areas in Brief**

1. 3, 1, 2 main sensory area
2. Visual or striate area—area 17. It has stria of Genneri and band of Beillerger
3. Area 6—premotor area for skillful acts learnt through repitative practice.
4. Area 8—Frontal eye field for congugate deviation of eyes
5. Area 9, 10, 11—Prefrontal cortex for personality change foresight and judgement.
6. Area 18, 19—for visual association area - interpretation of light on the basis of past experience
7. Auditory area—41, 42
8. Area 22—Association area (Recognises sound on previous experience. Sensory speech area. Person talks without knowing what he is talking (Word blindness)
9. Area 39—Angular gyrus-unable to read, i.e. alexia, unable to right-Agraphia
10. Area 40—Supramarginal gyrus. (39 and 40 belong to inferior parietal lobule) Tectile agnosia.

**Global Aphasia** Due to lesion in both the sensory and the motor area, patient cannot speak nor understand what he is speaking.

# INFERIOR SURFACE OF THE CEREBRAL HEMISPHERE

Inferior surface of the cerebral hemisphere is divided into the anterior one-third and posterior two-thirds through a line passing through the temporal poles. Anterior one-third is separated from the posterior two-thirds of the inferior surface, of the cerebral hemisphere by the stem of the lateral sulcus which finally reaches the superolateral surface.

The inferior surface infront of the stem of the lateral sulcus is known as the orbital surface, and one which lies posterior to the stem of the lateral sulcus is known as the tentorial. Two cerebral hemispheres are separated anteriorly by the median longitudinal fissure. Orbital lobe presents gyrus rectus, olfactory bulbs, olfactory tracts and its three roots. In addition to it it has the anterior, posterior, lateral and the medial orbital gyri. The tentorial surface has two sulci, the collateral and the occipito-temporal. Collateral sulcus is placed medially and forms the limit of the para-hipocampal gyrus. Anterior interrupted part of the collateral sulcus is known as the rhinal sulcus, medial to which lies the uncus.

Two optic nerves cross in the midline to form the optic chiasma and the optic tract. Optic tract joins the lateral geniculate body from which the optic radiations reach the occipital lobe. Lateral to the optic chiasma is the space known as valiculus. The roof of which is formed by the anterior perforated substance. Internal carotid artery divides into terminal branches namely the anterior and the middle cerebral. Behind the optic chiasma is the tubercenerium to which the pituitary is attached by means of an infundibulum. Behind the tubercenerium are the mamillary bodies and behind the mamillary bodies is the posterior perforated substance in an angle between the two cerebral pudencles.

The base of the cerebrum corresponds to the inter-pudencular cistern, which lodges the circle of Willis (Figure 314).

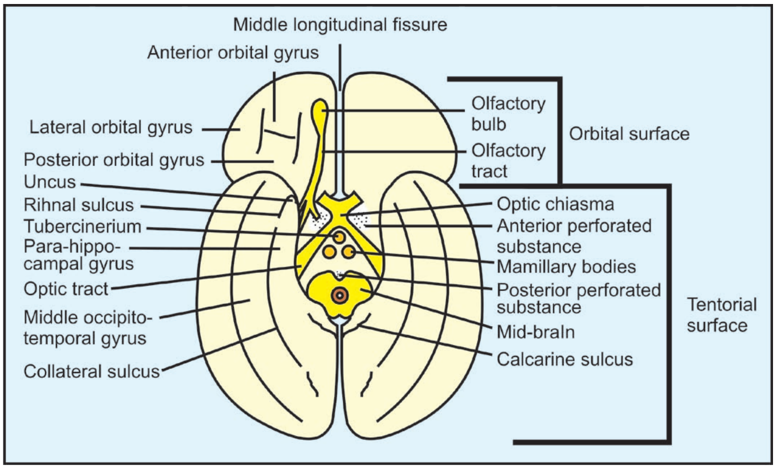



**Figure 314:** Showing inferior surface of the cerebrum

**Circle of Willis:** Circle of Willis is formed by the internal carotid, anterior cerebral and the posterior cerebral arteries. The basilar artery divides into posterior cerebral arteries which take part in the formation of circle of Willis.

It must be remembered that the middle cerebral artery does not take part in the formation of circle of Willis.

The circle of Willis is formed by the internal carotid artery, anterior cerebral, anterior communicating, posterior communicating and the posterior cerebral arteries. Congenital aneurysm on the circle of Willis are saccular. 30% of the sub-arachnoid hemorrhages in the yonger group are due to berry's aneurysm. In chronic hypertension the aneurysm are fusiform and are known as Chartcot-Bauchard aneurysm.

# MEDIAL SURFACE OF THE CEREBRAL HEMISPHERE

Two cerebral hemispheres are connected through the corpus callosum.

**Corpus Callosum:** Corpus collosum is the greatest commissural fiber which is placed more anteriorly than posteriorly. It occupies the lower 1/3rd of the medial surface of the cerebrum, It has rounded posterior end and the bent anterior.

Posterior end is known as the splenium and the anterior is known as the genu. Genu continues as the rostrum lower down. Rostrum is connected below to optic chiasma by means of lamina terminalis.

In front of the lamina terminalis, is the para-terminal gyrus. Behind optic chiasma is the tubercenerium. Tubercenerium is connected to the pituitary gland through the infundibulum (Figure 315).

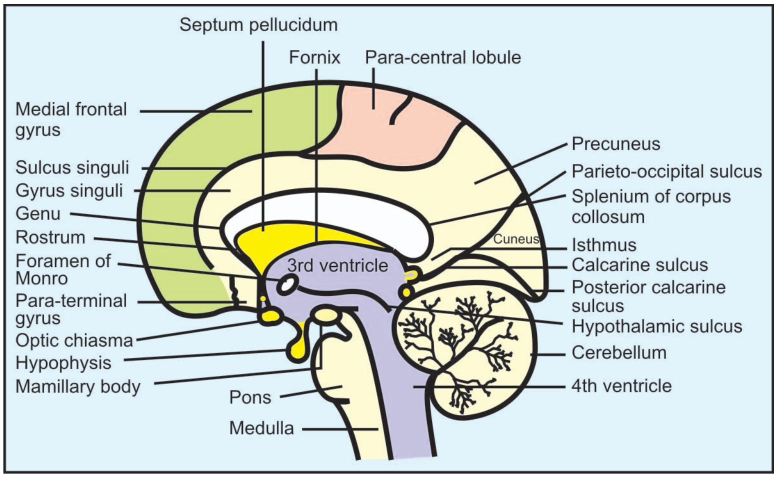



**Figure 315** Showing medial surface of the brain

Behind the tubercenerium are the mamillary bodies and behind them is the posterior perforated substance which lies in an angle between the two crura of the midbrain. Anterior perforated substance lies lateral to the optic chiasma. Opening of the aqueduct, pineal body and post-commissure form the posterior wall of the 3rd ventricle.

*Note:* Third ventricle is a cavity of diencephalon placed between the two thalami. Superior surface of corpus callosum is covex anteroposteriorly and the concave transversely. Corpus callosum is attached to the fornix in its anterior 2/3rd by the septum pellucidum which separates the two lateral ventricles.

Anteriorly fornix divides into two columns known as the anterior columns of the fornix. Anterior column of the fornix passes infront of the interventricular foramen and reaches the mamillary body. After relay in the body fibers go to the anterior nucleus of the thalamus. This tract is known as the mamillothalamic tract. Between the lamina terminalis and the anterior column of the fornix is the anterior commisure. Medial surface of the thalamus presents a groove running from the interventricular foramen to the cerebral aqueduct. It is known as the hypothalamic sulcus. Below the sulcus lies the hypothalamus. Anterior wall of the 3rd ventricle is formed by 3 structures as under anteroposteriorly.

1. Lamina terminalis
2. Anterior commissure
3. Anterior column of the fornix.

Anatomically hypothalamus corresponds to the floor of the 3rd ventricle. Medial surfaces of the thalami are connected by means of a mass of grey mater which is known as the connexus interthalamicus. Above the corpus callosum is the colosal sulcus and above it is cingulate gyrus. Sulcus cinguli arches around the gyrus cinguli and reaches the superomedial margin behind the central sulcus.

The area enclosed by sulcus cinguli, its up-turned posterior end, its offshut from the sulcus and the superomedial margin is known as the paracentral lobule. It contains the motor and sensory areas for the feet and the perineum.

Splenium of corpus callosum lies over the pineal gland.

**Floor of the Third Ventricle is Formed by the Following Structures from Before Backwards as Under:**

1. Optic chiasma
2. Tubercinerium
3. Infundibulum and pituitary
4. Mammilary bodies
5. Posterior perforated substance
6. The tegmentum.

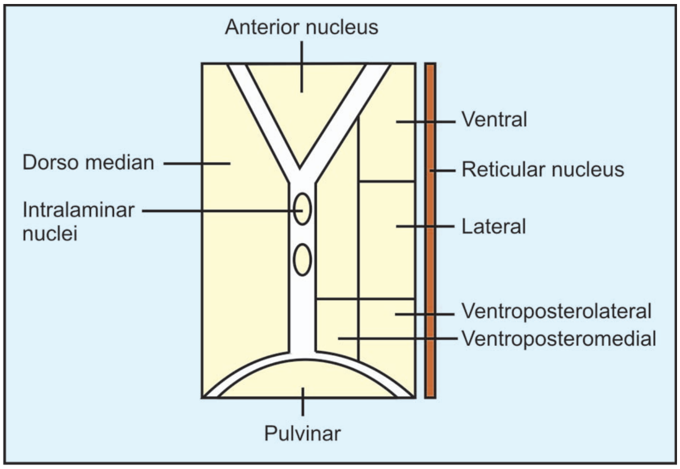
The roof of the third ventricle is formed by the fornix and the choroid plexus which hangs from the roof like a chandelier (Chandelier is a decorated hanging light from the root with many bulbs). Medial surface of the cerebral hemisphere between the sulcus cinguli and the supero-medial margin is known as the medial frontal gyrus. Calcaline sulcus begins below the splenium and divides into two sulci, i.e. the upper and the lower. The upper sulcus reaches the superomedial margin as parieto-occipital sulcus 5 cm infront of the occipital pole. The lower one goes to the occipital pole and is known as the post-calcarine sulcus. The area between two sulsi is known as the cuneus. The area above the cuneus is known as pre-cuneus. Lower down the para-hipocampal gyrus is seen on the tentorial surface of the cerebrum continues with the gyrus cingula through the isthmus. Isthmus is the part of the medial surface of the cerebral hemisphere lying between the splenium above and the calcaline sulcus below. Dorsal surface of the corpus callosum forms the floor of the medial longitudinal fissure and is covered with indusium griseum which contains medial and lateral longitudinal stria. Median longitudinal fissure is occupied by the falx cerebri, inferior sagittal sinus and the anterior cerebral arteries.

# THALAMUS

Thalamus is the head ganglion of the sensory system. Thalamus has the large sensory inputs through the ascending tracts in the brainstem like medial leminiscus, spinothalamic tract, spinal tract of the trigeminal, gustatory auditory and the visual. It has to sort out and process the received information and transfer it to the different areas of the cortex. It is done through the thalamic radiations. Vascular accidents in the brain affect the thalamic functions. The normal activity of the thalamic and the cortical neurons becomes abnormal. It causes an interesting signs and symptoms known as the thalamic syndrome.

**Thalamic Syndrome (Figures 316):** Pain, temperature and touch sensation on the opposite side of the body is dulled due to rise in the threshold in perception. The sensation received are most disaggreable, exaggerated and grossly perverted. Emotional disturbances lead to crying or laughing. It is all due to the abnormal thalamic and cortical neuronal activity.

**Figure 316** Showing some important nuclei of thalamus




**Thalamus Includes the Following Components:**

1. Thalamus
2. Hypothalamus
3. Subthalamus
4. Epithalamus.

**Thalamus:** Thalamus is an ovoid mass of grey mater, deeply buried in the cerebrum. Two thalami enclose the cavity of the third ventricle by forming its lateral walls. Thalamus has two poles and four surfaces.

**Anterior Pole:** Lies behind the interventricular foramen (Foramen of Monro).

**Posterior Pole:** Posterior lobe is broad and its medial prominent end is known as the pulvinar which lies above the superior colliculus. Inferolateral to the pulvinar are the medial and the lateral geniculate bodies.

## Surfaces

**Medial Surface:** Medial surface forms the lateral wall of the third ventricle. It has hypothalamic sulcus which runs downwards and backwards from the interventricular foramen to the opening of the aqueduct of the midbrain. Below the hypothalamic sulcus is the hypothalamus. It must be

remembered that the lower part of the lateral wall of the 3rd ventricle forms part of the hypothalamus. Two thalami are connected by the mass of grey mater. It is known as interthalamic connection. Medial surface of the thalamus is covered with the ependyma.

**Lateral Surface:** Lateral surface is related to the medial aspect of the posterior limb of the internal capsule.

**Superior Surface:** Superior surface is related to the fornix in the medial part. Between the fornix and the superior surface of the thalamus is the choroidal fissure which contains tela-choroidea of the third ventricle. The lateral part of the superior surface forms the floor of the body of the lateral ventricle.

**Inferior Surface:** Inferior surface is related to the hypothalamus, subthalamus, and the midbrain.

**Medullary lamini:** They are made up of white mater and are two, i.e. the intramedullary "Y" shaped lamina and the lateral medullary lamina which covers the lateral surface of the thalamus. "Y" shaped lamina grossly divides the substance of the thalamus into the anterior, medial and the lateral nuclei.

**Nuclei of the Thalamus:** As already stated the "Y" shaped intramedullary lamina divides the grey mater of the thalamus into three groups, i.e. anterior, medial and the lateral. The medial group is also known as the dorsomedial. Dorsal group is arranged in ventral and the dorsal groups. There are three nuclei in the ventral part of the lateral group arranged as under:

– Ventral anterior
– Ventral lateral
– Ventral posterior.

The ventral posterior is further divided into the ventroposterolateral and the ventroposteromedial nuclei. Dorsal part is divided as under, i.e. lateral dorsal nucleus, lateral posterior and the pulvinar. Other nuclei of the thalamus are as under:

1. Intralaminar nuclei
2. Midline nuclei
3. Reticulothalamic nuclei
4. Cenr-median nucleus.
5. Para-ventricular nuclei.

The thalamic radiations nuclei are placed between the posterior limb of the internal capsule and the extramedullary lamina.

**Connections of Thalamus:** Anterior nucleus of the thalamus receives fibers from the mammilary bodies in the form of mammilothalamic tract. The anterior nucleus of the thalamus is concerned with the emotions.

**Dorsomedial Nucleus:** Receives fibers from the pre-frontal gyra, 9th 10th and 11th. They are concerned with emotion and behavior.

The damage to the dorsomedial nucleus decreases anxity, tension, aggressiveness and loss of memory.

**Ventrolateral Mucleus:** Ventrolateral nucleus receives fibers from cerebellar nuclei, red nucleus and the substantia nigra. They regulate voluntary movements of the skeletal muscles and the tone. It is the integrity center for the cerebellum, substantia nigra and the cortex.

It is interesting to note that the surgical ablation of the ventrolateral nucleus is helpful in parkinsonial tremours.

**Ventropostero-Lateral Nucleus** The ventroposterolateral nucleus receives touch, pain, temperature and propriaceptive sensation from the opposite half of the body which is projected to the post-central gyrus in the form of superior thalamic radiations. Pulvinar is the integrity center for visual and auditory sensations.

**Centero-median and Parafloccular Nuclei:** Centro-median and parafloccular nuclei are the part of the ascending reticular activating system.

**Thalamic Radiations:** They are:

1. Anterior
2. Superior
3. Posterior

The superior and posterior radiations arise from ventroposterolateral and ventroposteromedial go to parietal lobe.

The posterior radiation go to the occipital cortex.

**Blood Supply of the Thalamus:** Blood supply comes from posterior communicating, posterior cerebral and basilar arteries.

**Functions of the Thalamus:**

1. It recieves fine sensations. It perceives crude sensations at the thalamic level.
2. It has a role in awakefulness and alertness due to its connection with the ascending activating system.
3. It controls voluntary movements by linking globus pallidus and the cerebellum to the motor and premotor cortex.

In brief it receives fine, perceives crude, awakefulness and controls voluntary movements.

# HYPOTHALAMUS

Hypothalamus is the head ganglion of the autonomic nervous system and controls the sympathetic and the parasympathetic system. Anatomically it corresponds to the floor of the third ventricle and the lower part of the lateral wall of the third ventricle below the hypothalamic sulcus.

**Parts**: Hypothalamus is divided into the following parts anteroposteriorly:

1. Pars optica
2. Pars tuberalis
3. Pars mamillaria
4. Posterior perforated substance.

**Nuclei (Figure 317):** Following are the nuclei of the hypothalamus

1. ***Pre-optic*****:** It releases gonadotropic hormone from the anterior lobe of pituitary.
2. ***Supraoptic*** *and paraventricular:* Axons of the neurons in the supra-optic and paraventricular nuclei carry secretary granules to the posterior lobe of the pituitary. Posterior lobe of the pituitary secrets ADH, oxytocin
3. ***Posterior nucleus***
4. ***Dorsimedial***
5. ***Ventrimedial:*** It is interesting to know and remember that the ventrimedial nucleus inhibits the desire to eat, hence known as satiety center.
6. ***Tuberal nuclei:*** It gives rise to the tuberohypophyseal tract which goes to the median eminence and terminates on the hypophyseal portal circulation.
7. ***Mamillary nuclei*** are connected to the hippocampus through the anterior column of fornix.

**Afferent Connections:**

1. Limbic system
2. Hippocampal formation
3. Amygdaloid nucleus through stria terminalis
4. Primary olfactory area
5. Brainstem
6. Dorso-median nucleus of thalamus.

**Efferent Connections:**

1. Septal area
2. Dorso-median nucleus
3. Amygdaloid nucleus
4. Brainstem reticular formation
5. Anterior lobe of the pituitary through portal circulation and
6. Neurohypophysis through hypothalamo, hypophyseal neural pathway.

**Functions of Hypothalamus:**

1. The anterior hypothalamus controls the parasympathetic neurons and the posterior hypothalamus control the sympathetic.
2. Temperature regulation
3. Water balance
4. Sex
5. Food
6. Emotions
7. ADH secretion
8. ***Oxytocin:*** Causes contraction of uterine muscle and the contraction of the myoepithelial cells of the mammary gland.

# SUBTHALAMUS

Subthalamus lies above the red nucleus and the substantia nigra. Lesion of the subthalamic nuclei produces hemiballismus.

# METATHALAMUS

Metathalamus inclues the lateral and the medial geniculate bodies.

**Lateral Geniculate Body:** It is ovoid in shape and is connected to the superior colliculus by of the superior brachium. Structurally, it is made up of six layers. Out of which 2, 3, 5 receive epsilateral fibers and 1, 4, 6 receive contralateral fibers of the optic tract. Afferent connections of the lateral geniculate body constitute the optic tract. They get relayed in the lateral geniculate body and reach the occipital cortex. This is the last neuron of the visual tract. Some of the fibers of the optic tract pass through the lateral geniculate body without relay and go to the superior coliculus through the superior brachium.

In the event of destruction of the lateral geniculate body the pupillary light reflex is retained as the fibers concerned have already left the lateral geniculate body. However the destruction of the left lateral genitculate body causes right homonimus hemiahopia.

# EPITHALAMUS

**Epithalamus Includes the Following:**
1. Pineal gland
2. Hebelunar nuclei
3. Posterior commissure.

**Pineal Gland:** Pineal gland is a small gland placed below the splenium of the corpus callosum. It is attached to the posterior wall of the third ventricle by means of a stalk containing a recess which is continuous with the cavity of the third ventricle. Upper lamina of the stalk gives passage to Hebelunar commissure and through the lower lamina passes the posterior commissure. Its nerve peanialis is photoreceptor in fish.

**Hebelunar Nuclei:** Hebelunar nuclei are the part of the limbic system and its function includes integration of olfactory and visceral functions.

**Posterior Commissure:** It connects the follows:
1. Pretactal nucleus
2. Interstitial nucleus of posterior commissure
3. Interstitial nucleus of Cajal
4. Nucleus of Darkshewitsch
5. Rostal interstitial nucleus of the medial longitudinal fasciculi of both side.

**Clinical:** Tumour of the pineal gland is uncommon. It may press the vertical gaze center in the midbrain and presents as Perinaud's syndrome. Pineal gland is no more considered as the pure vestigial organ. Probably it has an influence over the other endocrine glands. It produces melanotonin and its discharge is affected by the exposure of the animal to the light.

# THIRD VENTRICLE

Third ventricle is the cavity of diencephalon. It lies between the two thalami. Anteriorly it communicate with the two lateral ventricle through the interventricular foramen and posteriorly with the fourth ventricle through the aqueduct of the midbrain.

**Roof:** Roof of the third ventricle is formed by the fornix, choridal fissure and the choroid plexus. Choroid plexus of the third ventricle hangs down from the roof like a chandelier.

**Floor (Figure 317A):** Floor of the third ventricle is formed by the following structures antero-posteriorly.

1. Optic chiasma
2. Tuber cenerium with infundibulum and the pituitary
3. Mamillary bodies
4. Posterior perforated substance
5. Tegmentum of the midbrain.

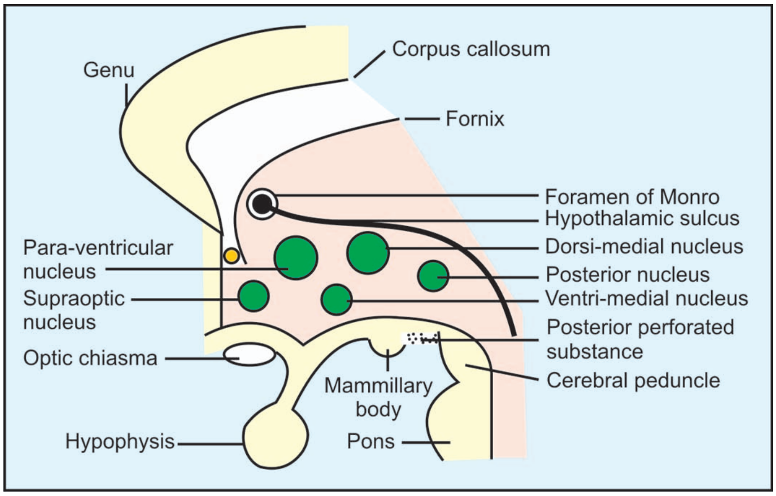



**Figure 317A** Showing important nuclei of hypothalamus

**Anterior Wall (Figures 317B to D)** Anterior wall of the third ventricle is formed by the three structures arranged anteroposteriorly as under:

1. Lamina terminalis
2. Anterior commissure
3. Anterior column of the fornix.

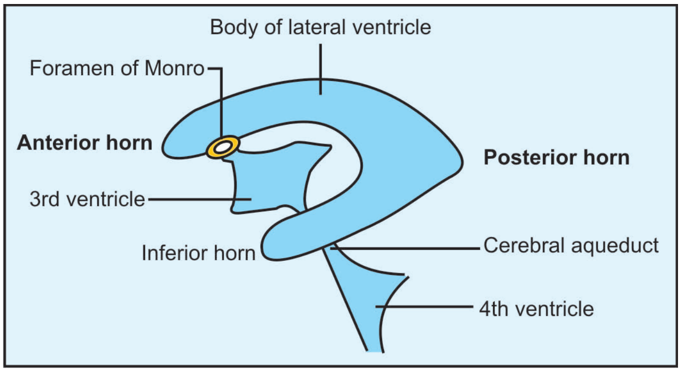



**Figure 317B** Showing ventricle of brain

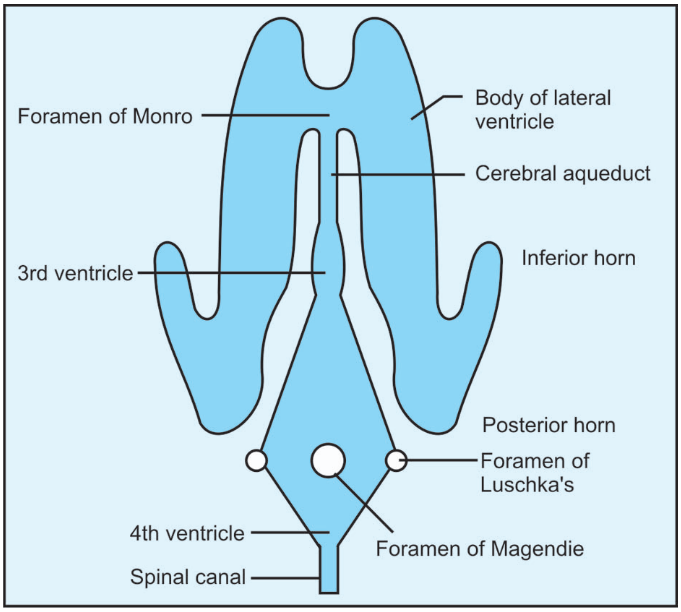



**Figure 317C** Showing ventricles of the brain as seen from above

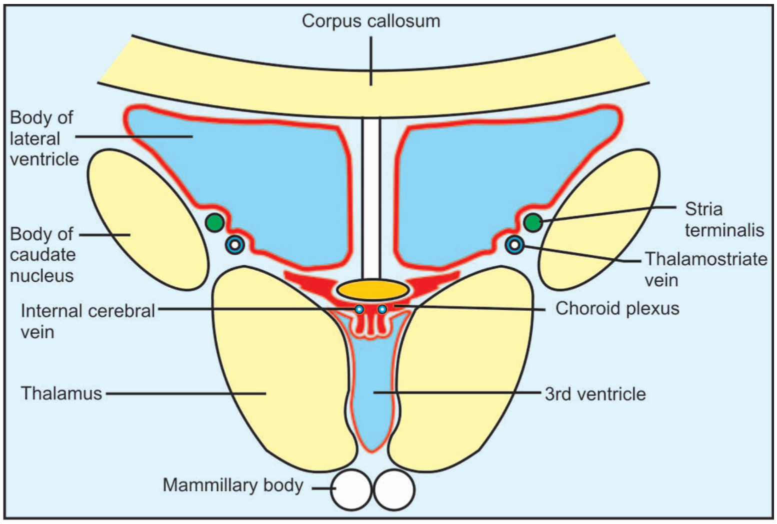



**Figure 317D** Showing coronal section of body of lateral ventricle at the level of mammillary body

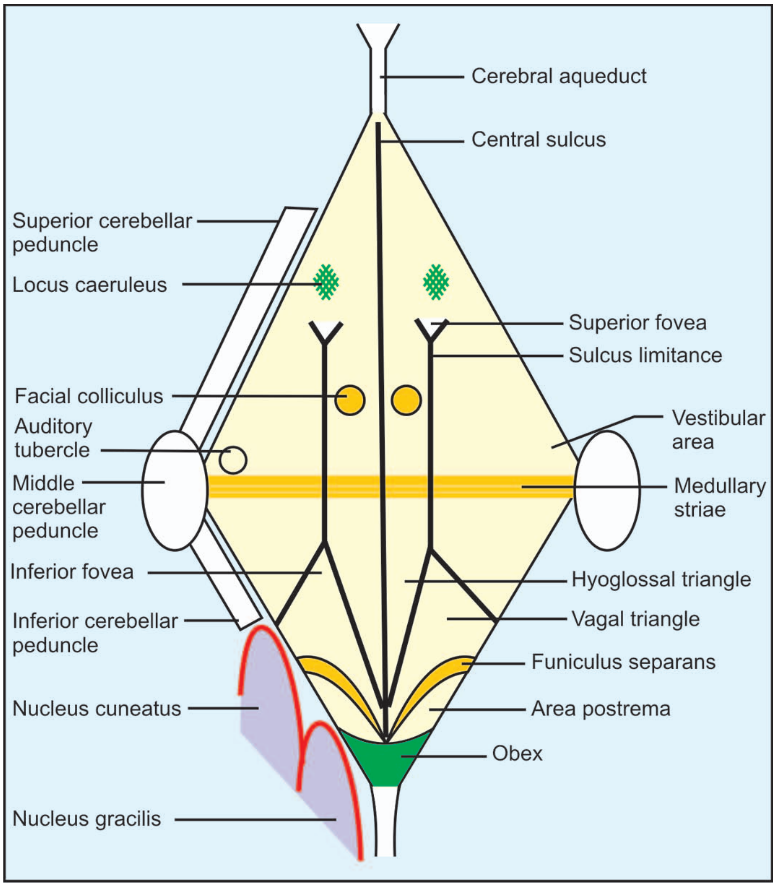
# FOURTH VENTRICLE

Fourth ventricle is the cavity of the hindbrain. Cranially it communicates the third ventricle by means of an aqueduct of Sylvius. Caudally it has communication with the central canal of the spinal cord. It is bounded by the pons and the medulla anteriorly and the cerebellum posteriorly. The roof of the fourth ventricle is like a tent formed by superior and the inferior medullary velli. Lower part of the roof of the fourth ventricle presents an opening known as the foramina of Magendie. The lateral angle of the fourth ventricle has foramina of Luschka.

**Floor of the Fourth Ventricle (Figure 317E):** Floor of the fourth ventricle is rhomboid in shape and its upper half part is formed by the pons and the lower by the medulla. It is limited by the following structures inferosuperiorly as under:

1. Nucleus gracilis
2. Nucleus cunieatus
3. Inferior cerebellar peduncle
4. Middle cerebellar peduncle
5. Superior cerebellar peduncle.

**Figure 317E** Showing floor of the 4th ventricle




**Note:** The lateral limit is also known as the lateral wall.

The floor is bisected in the middle by the median sulcus and laterally by the lateral sulcus on each side. In between the two lies the median eminence. The lateral sulcus divides half heartedly above producing the

superior fovea and whole heartedly below producing two triangles and interior fovea. The triangle hypoglossal is medial and the vagal lateral. In the pontine part of the median eminence is a rounded eminence known as the facial calliculus. The facial calliculus is produced by winding round of the fibers of the seventh around the nucleus of the sixth. Lateral to the superior fovea is an area known as locus coeruleus. It looks dark and is known as the substantia of ferrugenia. Under the hypoglossal triangle lies the nucleus of the hypoglossal nerve and under the vagal is the nucleus of the tenth. Vagal triangle shows a raised linear area known as funiculus separans. Lateral to the funiculus separans lies the area postrema which contains tanycytes and has no blood-brain barrier. Inferior angle of the fourth ventricle has a look of an inverted nib of a fountain pen. It is known as calamus scriptorius. The apex of the lower end of the floor of the fourth ventricle is known as the obex. Lateral angle of the fourth ventricle is the area for the vestibular and the chochlear nerve nuclei. Vestibular area is lateral to the fovea. Its lateral extension forms the auditory tubercle, under which lies the dorsal cochlear nucleus and the cochlear nerve. Fibers passing from the arcuate nucleus to the cerebellum of the opposite half form stria medullaries. They are represented by the transverse lines.

**Roof of the Fourth Ventricle**: Upper part of the roof of the fourth ventricle is formed by the superior medullary velum, which covers the superior cerebellar peduncles. Lower part of the roof of the fourth ventricle is mainly formed by the tella choroidea of the fourth ventricle. Tella choroidea is made up of double fold of pia mater and the ependyma. Inferior medullary velum occupies the lower part of the roof and lies infront of the cerebellar tonsils. Inferior medullary velum merges with white matter of the cerebellum. Peduncle of the flocculus is formed by the thick margin of the inferior medullary velum. Lower part of the roof has an midline opening known as foramina of Magendie. CSF enters the cisterna magna through the foramina of Magendie from the ventricular cavity.

**Recesses**: Roof of the fourth ventricle has three dorsal recesses. The median dorsal recess extends into the cerebellum, superior to the nodule, the lateral dorsal recesses project into the white matter of the cerebellum lateral to the nodule and above the medullary velum. Lateral recess of each side reaches the flocculus and open in the subarachnoid space through the formina of Luschka.

**Choroid Plexus:** Choroid plexus of the fourth ventricle is formed by the tella choridea and the branches from the posterinferior cerebellar artery. The choroid plexus of the fourth ventricle is arranged into two vertical and two transverse limbs. Vertical limbs run lateral to the foramen of Magendie and transversly running limbs go to the lateral recesses.

**Clinical** The commonest tumor of the fourth ventricle is an ependymoma which obstructs the circulation of the CSF and causes hydrocephalus.

# LATERAL VENTRICLES OF THE CEREBRAL HEMISPHERES

Lateral ventricles are paired occupying the cerebral hemispheres of the right and the left. Each lateral ventricle has the body, anterior, posterior and the inferior horns. They are connected anteriorly through the foramen known as the interventricular foramen (Foramina of Monro). The interventricular foramen also connects the lateral ventricles to the third ventricle. Third ventricle is the cavity of diencephalon and lies between the two thalami. The third ventricle communicates with the fourth through the cerebral aqueduct which passes through the midbrain (Figures 317F to I).

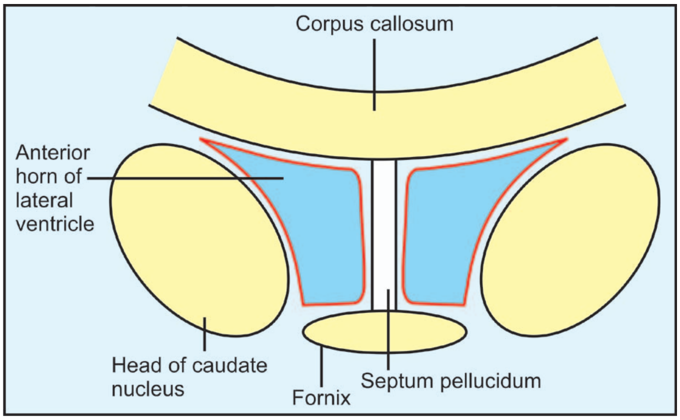



**Figure 317F** Showing coronal section to the anterior horn of the lateral ventricle

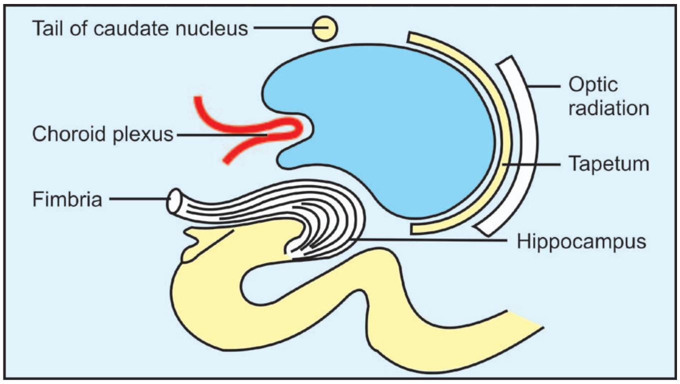



**Figure 317G** Showing floor and lateral wall of inferior horn of lateral ventricle. Please note the tail of caudate nucleus at the roof

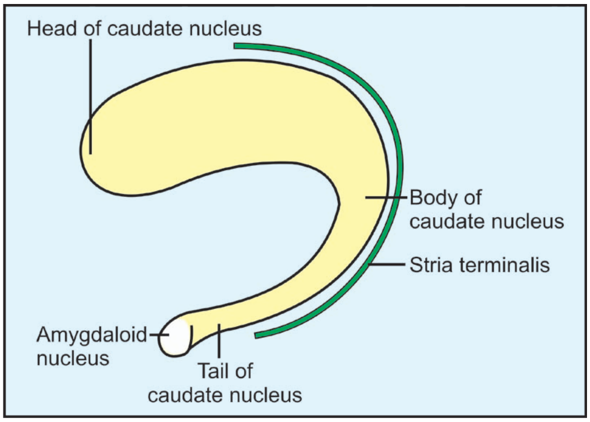



**Figure 317H** Showing caudate nucleus

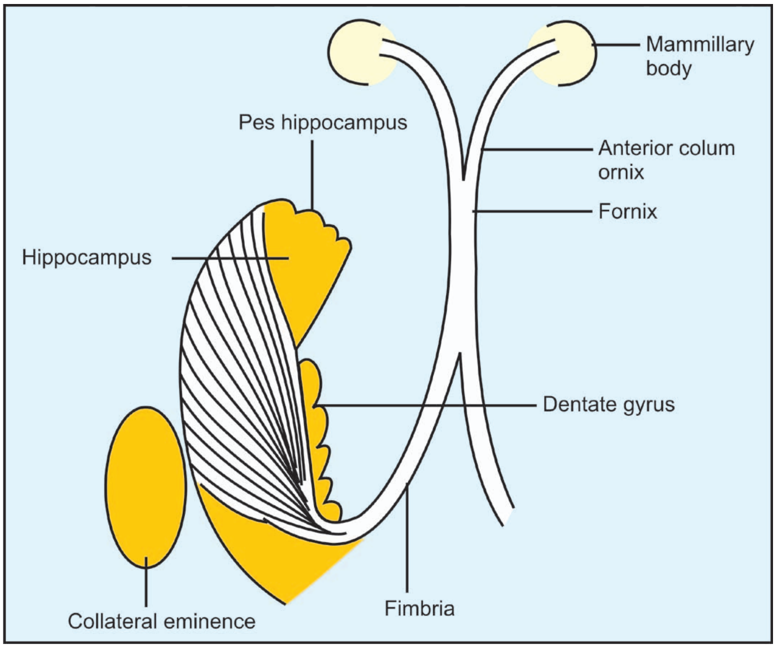



**Figure 317I** Showing floor of the inferior horn of the lateral ventricle. The floor is formed by dentate gyrus, hippocampus coverd with alveus and collateral eminence from medial to lateral side

## Anterior Horn of the Lateral Ventricle

**Roof:** Roof is formed by the corpus callosum.

**Medial Wall:** Medial wall is formed by the septum pellucidum.

**Lateral Wall:** Lateral wall is formed by the head of the caudate nucleus.

**Floor:** Floor is formed by the rostrum.

**Note:** Anterior horn of the lateral ventricle does not have the choroid plexus.

Body of the lateral ventricle

**Roof:** Roof is formed by the corpus callosum.

**Medial Wall:** Medial wall is formed by the septum pellucidum.

**Floor:** Floor is formed by the following structures from medial to lateral side.

1. Fornix
2. Choroid plexus
3. Superior surface of the thalamus
4. Thalamo-striate vein
5. Strai semicircularis
6. The body of the caudate nucleus.

**Note:** The cavity of the body of the lateral ventricle is lined by the ependyma like any other ventricular cavity and the choroid plexus of the lateral ventricle communicates with the choroid plexus of the third ventricle through the curved slit like gap known as the choroidal fissure.

## Posterior Horn of the Lateral Ventricle

**Roof:** Roof is formed by the tapetum and the optic radiation.

**Floor:** Floor is formed by two elevations namely the bulb of the posterior horn and the calcar avis.

**Note:** The bulb of the posterior horn is formed by the forceps major of the corpus callosum and the calcar avis is formed by the calcarine sulcus which is classified as the complete sulcus. Complete sulcus is one which produces an elevation inside the ventricle. Posterior horn of the lateral ventricle does not have the choroid plexus.

## Inferior Horn of the Lateral Ventricle

**Roof**: Roof is formed by the tail of the caudate nucleus amygdaloid nucleus and the stria-semicircularis.

**Floor:** Floor of the inferior horn of the lateral ventricle is formed by following structures from median to lateral side.

1. Dentate gyrus
2. Fimbria
3. Hippocampus with peshippocampus covered with white fibers known as the alvius.
4. Collateral eminence.

**Note:** Lateral to the collateral eminence is the collateral triangle.

**Lateral Wall:** Lateral wall of the inferior horn of the lateral ventricle is formed by the tapetum. It has choroid plexus.

**Tapetum:** Tapetum is formed by the fibres of the corpus callosum arising near the splenium which are not intersected by the fibers of the pyramidal tract.

# LIMBIC SYSTEM

Limbic system comprises of cerebrum, diencephalon, midbrain. Limbic system is filled to the brim by long list of components and connections. It is a system which is concerned with emotional expression.

It has mainly three structural components.

1. Cortical area
2. Sub-cortical area and
3. Fibers

*Sub-cortical grey mater includes the following.*

1. Dorsomedial nucleus of thalamus.
2. Hypothalamus
3. Midbrain
4. Septal nuclei
5. Interpudencular nucleus
6. Hebelunar nucleus and
7. Amygdala.

*Fibers are as under:*

1. Mamillo-thalamic tract,
2. Stria-terminalis
3. Stria-medullary thalami
4. Median forebrain bundle
5. Diagonal band of Brocha's.

**Amygdaloid Nucleus:** It is the sub-cortical mass of the grey mater placed inside the uncus in the anterior part of the roof of the inferior horn of the lateral ventricle. It has continuity with caudate nucleus, clostrum and the lentiform nuclei. Amygdaloid nucleus forms the important component of the limbic systems hence, it tops the list of the structures responsible for emotions and human behavior.

## Connections

**Subcortical Stria Terminalis:** It starts its journey from the amygdaloid nucleus goes posteriorly along the roof of the inferior roof of the lateral ventricle as it continues upwards and forwards it comes to lie in the floor of the body of the lateral ventricle, and reaches the foramen of Monro where it divides into three parts.

a. Supra-commissural: It goes to para-hippocampal gyrus.
b. Commissural part passes through the anterior commissure to reach the amygdaloid nucleus of the other side.
c. Sub-commissural part joins the anterior hypothalamic nuclei and the anterior perforated substance.
d. Ventral amygdaloid-fugal fibers go to the septal nuclei, anterior perforated substance, medial dorsal nucleus of thalamus, hypothalamic nuclei and the basal nucleus. It has connections with midbrain, and corpus striatum.

*Sub-cortical connections of the amygdaloid:*

1. Enterorhinal cortex
2. Hippocampal cortex
3. Temporal cortex

4. Occipital cortex
5. Frontal cortex
6. Insular cortex and
7. Cingular cortex.

**Hippocampal Formation:** Hippocampal formation includes, hippocampus, dentate gyrus, medial and lateral longitudinal stria.

**Papez Circuit:** Papez circuit is a ring connecting the structures forming the limbic system. Hippocampus to mamillary body through the fornix, mamillary body to anterior nucleus of thalamus through mamillo-thalamic tract and the anterior nucleus of thalamus to gyrus cinguli and from there to the cingulum which comes back to the hippocampus. Lesion of the mamillary body leads to Korsakoff syndrome, in which there is gross impairment of memory. Hippocampus is concerned with learning, recent memory and emotional behavior.

**Limbic Lobe** It includes septal area, cingular gyrus, isthmus and the parahippocampal gyrus. Parahippocampal limbic lobe includes septal area, gyrus cingular, isthmaus and gyrus.

Septal area includes septum pellucidum, parahippocampal gyrus and the subcallosal gyrus. Enterorhinal area consists of the following:

1. Anterior part of parahippocampal gyrus
2. Uncus.

**Clinical:** Destruction of hippocampus causes long-term memory loss. Bilateral destruction of the amygdaloid and hippocampus lead to Kluver Buch syndrome (Hyperphagia and hyper-sexuality). Negri bodies are found in persons dying of rabies. Destruction of the mamillary body leads to Korsakoff syndrome in which there is severe impairment of memory.

**Basal Nucleus of Meyert:** Basal nucleus of Meyert is situated between the globus pallidus and anterior perforated substance. It projects to the amygdaloid and the neocortex. Lesion of the cingulate gyrus leads to akinesia, mutisum apathy and indifference to pain. Enterorhinal area includes the anterior part of the parahippocampal gyrus including the uncus.

# BASAL GANGLIA

Functionally they are the parts of the extrapyramidal system. Following structures are included in the category of the basal ganglia.

1. Amygdaloid nucleus
2. Claustrum
3. Caudate nucleus
4. Lentiform nucleus.

**Aid to Memory:** ACC Ltd. (Associated Cement Co. Limited

A = Amygdaloid nucleus
C = Calustrum
C = Caudate nucleus
L = Lentiform nucleus.

**Corpus Striatum**: It is formed by the caudate and the lentiform nuclei.

**Striatum:** Head of the caudate and the putamen of the lentiform nucleus are connected by fibers in the anterior part. It has a striated appearance.

**Pallidum:** Pallidum is formed by the medial part of the lentiform nucleus known as pallidum.

**Connections (Figure 317):** Afferent connections of the striatum:

1. Corticostriate
2. Thalamostriate
3. Nigro striate.

**Efferent Connections of the Striatum:** Efferent connections of the straitum goes to pallidum only

Efferent connections of the pallidum

1. Pallido-subthalamic
2. Pallido-thalamic
3. Pallido-rubral
4. Pallido-reticular
5. Olivo-spinal

These connections controls the lower motor neuron as under :

i. Rubrospinal:
ii. Reticulospinal:
iii. Olivospinal
iv. Rubromedullary
v. Reticulomedullary
vi. Olivo-medullary

It is seen from the above that the corpus striatum which is the head ganglion of the extrapyramidal system. The corpus striatum controls the lower motor neurons and the concerned muscles through their spinal and bulber tracts.

**Functions**: Extrapyramidal system co-ordinates muscle tone and contractions which is under sub-conscious control. It controls the lower motor neurons indirectly.

It informs the cortex before the impulses of the cortex come down to the muscles. The lesion of the corpus striatum is basically begins with starting and the stopping of the movements. In fact the corpus striatum is described as a controlling brake of the muscular movements, to make them work in the cordinated way.

Lesion of the basal ganglion (Corpus striatum) causes disturbance in the movement of the muscles.

| | |
|---|---|
| **Parkinsonism:** | In this disease the dopamine concentration of the corpus striatum becomes less due to the degeneration of neurons of subtantia nigra.<br>A patient of parkinsonism has a mask like face static and intentional tremors and chorioathetoid type of movements. |
| **Huntington's Chorea:** | The neurons in the caudate and putamen get degenerated. |
| **Sydenham's Chorea:** | Results due to the vascular pathology in the corpus striatum (Microhaemorrhages). |
| **Hepato-lenticular Degeneration (Wilson's Disease)** | It is associated with the defective copper metabolism. Copper gets deposited in the lentiform nucleus and the cornea. In cornea the deposition of the copper presents in the form of Kayser-Fleischer's ring. |

# OLFACTORY NERVE

Olfactory nerve is the first cranial nerve. It has bipolar neurons in the olfactory mucosa, which is the first order of neurons, it is not derived from the neuroectoderm. It ows its origin to the surface ectoderm. Second order neurone is in the olfactory bulb.

Minute 20 nerves pass through the cribriform plate to enter the anterior cranial fossa, where they join the olfactory bulb. Being part of the brain it is provided with all the three meningeal layers. The subarachnoid space makes connections with the lymphatics of the nose. Veins from the nose enter the cranial cavity and join the superior sagittal sinus. This provides an easy entry for the infection from the roof of nose to enter the sub-arachnoid space. Hence, the roof of the nose is the *Danger area* of the nose.

Hence, danger areas are:

1. Danger area of face
2. Danger area of scalp
3. Danger area of roof of nose.

Olfactory tract begins from the posterior end of the olfactory bulb, travels posteriorly and reaches the anterior perforated substance. It has three strias. Medial stria goes to the paraterminal gyrus. Lateral stria goes to the primary olfactory cortex and the middle stria goes to the anterior perforated substance. Olfactory cortex comprises of anterior perforated substance, lateral olfactory gray, amygdaloid, olfactory area 28.

**Cranial Nerve 13 or Mysterious Cranial Nerve:** It is also known as "0" nerve.

**Optic Nerve:** It begins in the orbital cavity as the axons of the ganglion cells. It has all the three meninges. Hence, when the intracranial pressure is raised central vein of retina is blocked or compressed preventing the venous return from the eyeball which leads to papilloedema.

Visual impulse passes from retina to the visual cortex area 17. Rods and cones of the retina are photoreceptors cells. They convert light signals into electricals. Neurons in the retina, bipolar cells form the first order of neuron and the ganglion cells forms the second. Length of the optic nerve is 4 cm. Optic nerve, is described as having three parts (Figure 317J).

1. Orbital
2. Canalicular, and
3. Cranial.

In the orbit the optic nerve is crossed by three structures superiorly from lateral to medial aspect. They are naso-ciliary nerve, ophthalmic artery and the ophthlamic vein. (Nerve, artery and vein).

**Blood Supply of Optic Nerve (Figure 317 K):** It is supplied by the ophthalmic artery branch of the internal carotid artery.

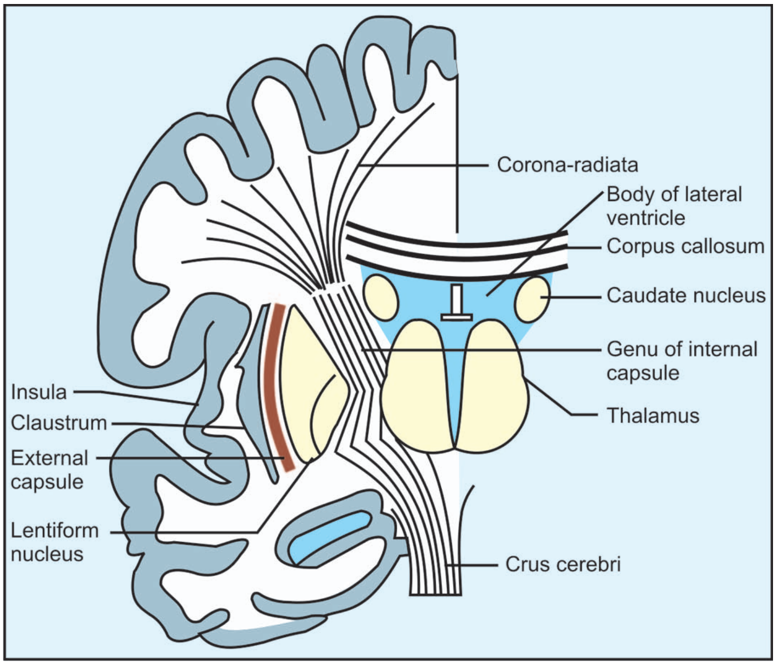



**Figure 317J** Coronal section of cerebrum showing insular cortex, claustrum and external capsule with internal capsule between caudate and thalamus medially and lentiform nucleus laterally

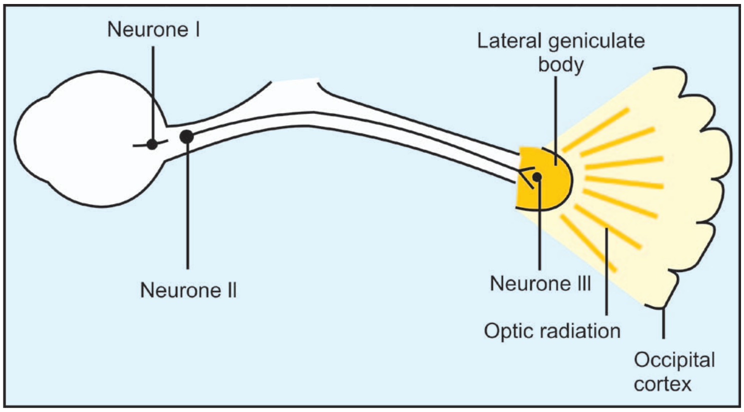



**Figure 317K** Showing neurones along the visual pathway

**Willibrandt's Knee:** Nasal fibers in the optic nerve enters the optic tract of the opposite side, and returns back to the optic tract of the same side forming a bend which is known as Willibrandt's knee

Blood supply of optic chiasma:

1. Anterior cerebral
2. Internal caotid
3. Posterior communicating
4. Middle cerebral

**The Effect of Lesions of the Visual Pathway:** Optic nerve of right side:

1. Lesion of optic nerve causes ipsilateral blindness
2. Sagittal section of the optic chiasma causes homonemous hemianopia
3. Lesion of the optic tract causes contralateral homonymous hemianopia
4. Optic radiation causes contralateral hemianopia.

**Lesion of Visual Cortex** Contralateral homonymous hemianopia with macular spairing. In the destruction of the lateral geniculate body, the pupillary reflex remains unaffected as the concerned fibers leave the lateral geniculate body long before.

**Summary of Visual Pathway:** The visual pathway includes the following:

1. Retina
2. Optic nerve

3. Optic chiasma
4. Lateral geniculate body
5. Optic radiation
6. Visual cortex.

There are two important reflexes which are mediated through the visual pathway.

**Light Reflex:** The impulses carried from the retina through the optic nerve, optic chiasma and optic tract, enter the lateral geniculate body and after relay the fibers of the visual pathway leave as the optic radiation and reaches the visual cortex. However, some fibers pass through the lateral geniculate body without relay, enter the superior brachium, reach the superior colliculi and the pretectial nucleus. The fibers from the pretectal nucleus follow the path of the oculomotor nerve and reaches the pupil. If light is thrown into the right eye there is constriction of pupil of the right eye as well as there is consensual constriction of the pupil of the left.

**Accommodation Reflex:** The size of the pupil and the ciliary muscle change which regulate the pupillary aperture and contraction or relaxation the cilliary muscle which change the shape of the lens.

# BLOOD SUPPLY OF BRAIN

Brain is supplied by the internal carotid and the basi-vertebral systems. Internal carotid artery gives anterior and the middle cerebral arteries. Two vertebral arteries unite to form the basilar artery which divides into posterior cerebral arteries. Blood is the main source of oxygen for the brain. Brain consumes one-fourth of the total oxygen inhaled. Lack of blood supply for 6 to 7 seconds causes unconsciousness which results in death of nerve cells. The death of nerve cells is permanent. You are born with the fixed number of nerve cells and die with the same unless if you do not loose them in head injury or the cerebrovascular episodes. It must be remembered that there is no regeneration in the central nervous system being highly evolved.

**Internal Carotid Artery:** It is one of the two terminal branches of the common carotid given at the level of upper border of thyroid cartilage. It enters the cranial cavity through the carotid canal and enters the cavernous sinus. It comes out of the cavernous sinus and makes a backward bend and divides into the anterior and middle cerebral arteries lateral to the optic chiasma.

**Branches of the internal carotid artery are divided into three regions (Figures 318 and 319):**

1. Intrapetrous–Carotico-tympanic and pterygoid.
2. In the cavernous sinus–Hypophyseal, trigeminal,
3. Supraclenoid part–Ophthalmic, anterior choroidal, posterior **communicating**, branch of internal capsule, anterior and the middle **cerebral** arteries.

**Figure 318** Showing blood supply of superolateral surface of cerebrum

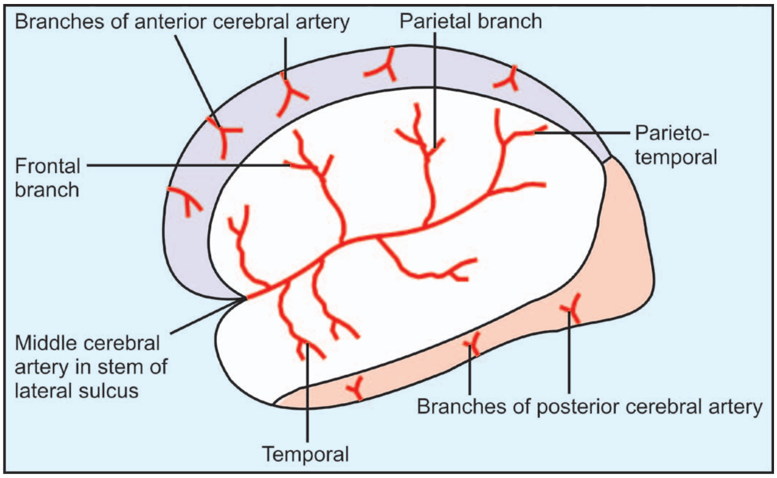
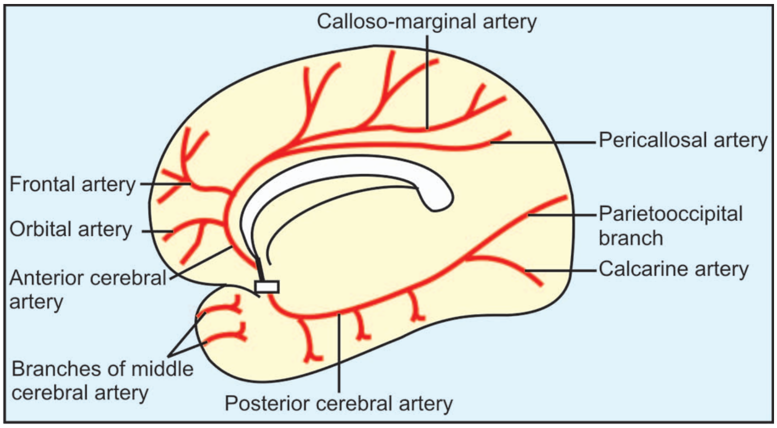



**Figure 319** Showing arterior supply of medial and infero-lateral surface of cerebrum



**Vertebro-basilar System:** Two vertebral arteries unite at the lower border of the pons and form the basilar artery. Basilar artery lies in the median groove on the ventral surface of the pons.

It gives following branches:

1. Two posterior cerebral artery.
2. Superior cerebellar
3. Anterior inferior cerebellar
4. Pontine
5. Labyrinthine artery.

It commonly arises from the anterior inferior cerebellar artery hence known as cerebellolabyrinthine artery.

**Circle of Willis:** Circle of Willis is an arterial circle situated inside the cranium at the base of the cerebrum in the basilar cistern. It is formed by the following arteries.

1. Anterior cerebral,
2. Anterior communicating,
3. Posterior communicating,
4. Posterior cerebral, and
5. Internal carotid artery.

Please note that the middle cerebral artery does not contribute to the formation of the circle of Willis. The circle of Willis equalises the pressure in the internal carotid artery and the verteral system (Figure 319A).

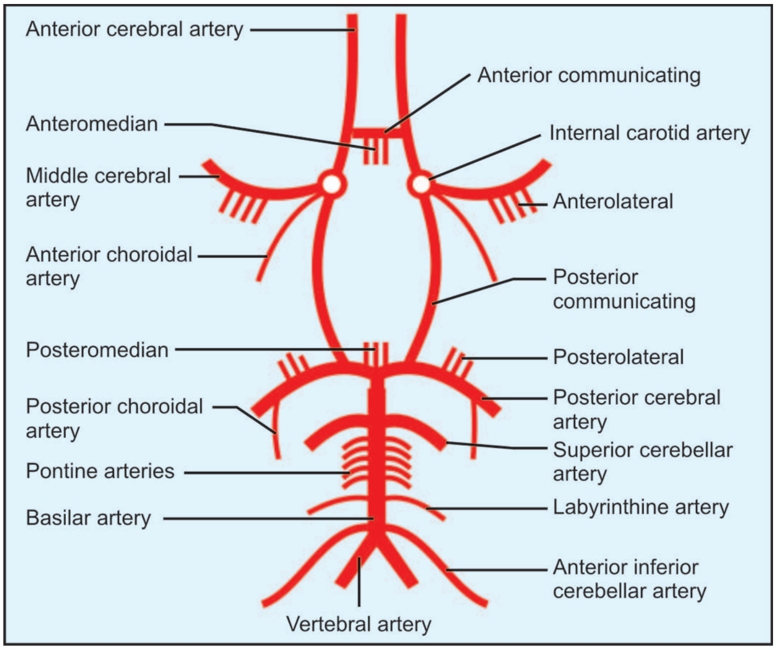
Berry aneurysm occurs as the congenital weakness of the walls of the vessels forming the circle of the Willis. They are saccular. Rupture of the aneurysm causes sub-arachnoid haemorrhage.

The branches of the circle of Willis are arranged in following groups:

1. Anterior
2. Anterolateral
3. Posterolateral

Anterior group of branches arise from the anterior communicating arteries. The striate arteries supplying the internal capsule arise from the anterior and the middle cerebral arteries in two groups the medial and the lateral. One branch from the lateral striate groups runs on the lateral surface of the lentiform nucleus, pierces it and supplies the internal capsule. It is known as artery of Charcot and has achieved the distinction of becoming an artery of the cerebral haemorrhage. One artery from the medial striate group is larger and is known as Huebener's artery.

**Figure 319A** Showing circle of Willis



**Anterior Choroidal Arteries:** Anterior choroidal artery arises from the internal carotid artery near the origin of posterior communicating. It passes posteriorly above the uncus and crosses the optic tract from lateral to medial side to reach the interpeduncular fossa. It supplies the crus cerebri and turns laterally to cross the optic tract for the second time and runs lateral to the lateral geniculate body and finally enters the inferior horn of the lateral ventricle to form the choroid plexus.

Being small in caliber and long in length the artery is likey to get compressed and thrombosed.

**Posterior Choroidal Artery (Figure 320):** Posterior Choroidal artery arises from the posterior cerebral artery and has three sets one medial and two lateral. They take part in the formation of the choroid plexus of the lateral and the third ventricles.

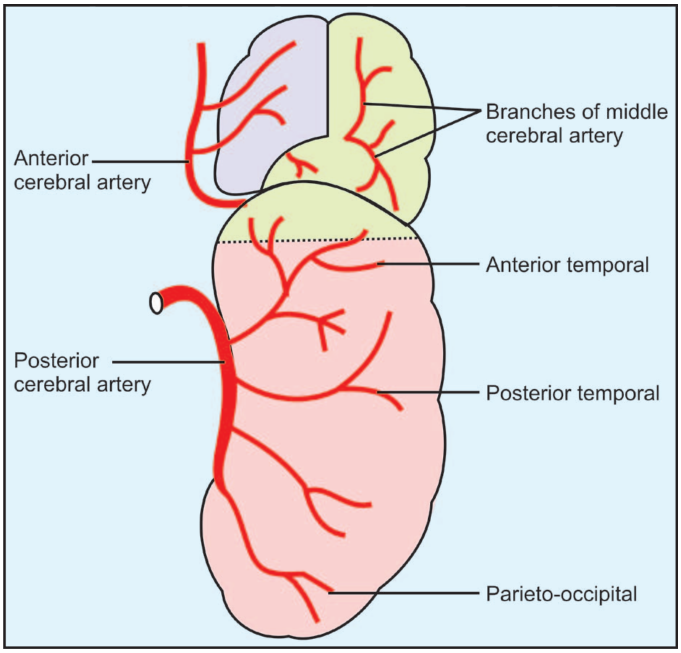



**Figure 320** Showing blood supply of inferior surface of the cerebral

**Occlusion of the Anterior Cerebral Artery:** Occlusion of the anterior cerebral artery deprives the paracentral lobule of its blood supply.

**Clinical:** The result is seen as hemiplegia and urinary incontinence with altered sensorium of the lower limb. Artery of Huebener supplies the genu of the internal capsule. Its occlusion causes contralateral paresis of the upper limb, tongue and the lower half of the face.

**Middle Cerebral Artery:** Occlusion of the medial cerebral artery causes contralateral spanstic paralysis of the upper limb, lower part of the face altered sensorium and the conjugate deviation of the eyes to the side of the lesion. It is due to the involvement of the posterior part of the middle, frontal gyrus (The area of conjugate deviation of eyes).

Blockage of the posterior cerebral artery causes homonimus hemianopia and distortion of colours, due to involvement of associated occipital cortical area.

**Angiography:** Internal carotid angiography is performed by puncturing the artery directly and injecting the dye, under general anaesthesia. The vertebral arteries are approach through the femoral artery by reaching the arch of aorta and brachiocephalic on the right and the left subclavian, through the catheter.

Loss of blood supply to the the para-central lobule leads to contralateral hemiplegia, urinary incontinence and altered sensorium of the lower limb.

**Striate Arteries:** They arise from the middle and the anterior cerebral arteries and pass through the anterior perforated substance to reach the structures inside the cerebrum. Artery of Charcot belongs to lateral striate group.

**Artery of Huebener:** It belongs to the medial striate group. It passes through the anterior perforated substance to supply the internal capsule.

# VENOUS DRAINAGE OF THE BRAIN

**Venous Drainage:** Venous drainage of the cerebrum is divided into external and the internal. Superior cerebral veins drain into the superior sagittal sinus. They run forward with an oblique course. Blood flow in the superior cerebral veins is against the direction of the blood flow of the superior sagittal sinus.

**Clinical:** During head injury due to distortion and displacement of cerebrum causes rupture of the veins resulting in subdural haematoma.

It is of interest to know that the subdural haematoma can be caused by minor dash of the head against the wall and violent cough and violent sneeze. Such injuries are forgotton. Gradually patient develops spells of unconsciousness which is fluctuating. The diagnosis of the subdural haematoma is done by MRI of the skull. Skull is trephined, the dura is exposed and cut and the underlying haematoma is removed. The recovery of the patient after surgery is remarkable.

**Vein of Troland (Figure 321):** Vein of Troland connects the superficial middle cerebral veins to the superior sagittal sinus, and the veins of Labbe connect the superficial middle cerebral veins to the transverse sinus.

Deep cerebral vein drains the insula and returns to the vallecula. Basal vein is formed at the vallecula by union of anterior cerebral, deep middle cerebral and striate veins. It goes posteriorly and opens into the great cerebral vein.

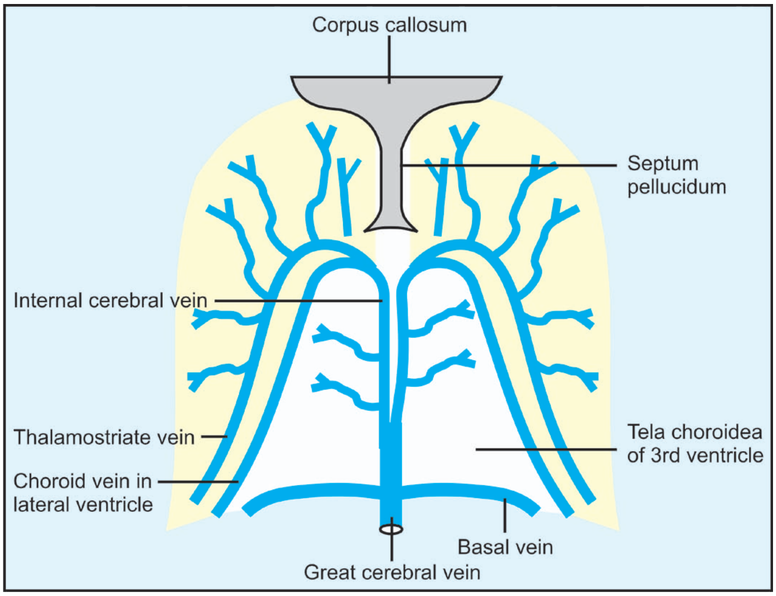



**Figure 321** Showing formation of internal cerebral vein

**Deep Veins of the Cerebrum:** They are the striate and the choroidal veins.

Deep middle cerebral vein receives veins froms the insula and reaches the base of the cerebrum at vallecula. Anterior cerebral vein goes in company with the anterior cerebral artery on the superior surface of the corpus callosum and reaches the anterior perforated substance. Basal ring is formed at the anterior perforated substance by union of anterior cerebral, deep medial cerebral and the striate veins. It goes posteriorly, follows the optic tract, crosses the crus cerebri and opens in the great cerebral vein under the splenium of the corpus callosum. Internal cerebral veins drain the orbital and tentorial surfaces. The veins from the orbital

surface join the superior cerebral veins which open into the superior sagittal sinus. The veins of the tentorial surface join the transverse sinus.

1. ***Thalamostriate vein:*** Runs on the floor of the body of the lateral ventricle between the caudate nucleus laterally and thalamus medially. It drains thalamus, corpus striatum and the internal capsule.
2. ***Choroidal vein:*** Choroidal vein is in the company of the choroid plexus of the lateral ventricle. It drains hippocampus, corpus callosum and the fornix. It runs towards the inter-ventricular foramen.

Internal cerebral vein is formed at the inter-ventricular foramina by union of thalamostriate and choroidal veins. Both of them go backwards in the telachoroidea of the third ventricle and join together under the splenium to form the great cerebral vein of Gallen. Vein of Gallen is short and is placed in the cisterna ambiance under the splenium of the corpus callosum. It receives right and left basal veins and the veins from the cerebellum, pineal gland and tectum. It joins the inferior sagittal sinus to form the straight sinus. The site of union of the great cerebral vein of Gallen with the straight sinus has a sinusoidal plexus, which regulates blood flow coming from the great cerebral vein of the Gallen to the straight sinus.

**Clinical:** Early obliteration of the sutures of the skull leads to deformities of the skull such as scaphocephaly. Restricted growth of the skull can lead to the obstruction of venous drainage at the base of the skull which is commonly associated with craniosynostosis.

# RETICULAR FORMATION

Reticular formation is composed of cells and fibers running up and down transversely and obliquely. It is present throughout the brainstem. It has been named regionwise as under:

1. Mesencephalic reticular formation
2. Pontine reticular formation
3. Medullary reticular formation.

In medulla the reticular formation is situated behind the olivary nucleus and is called as the retro-olivary complex. It must be remembered that the blood supply of the retroolivery complex comes from the posterior inferior cerebellar artery.

**Columns:** Reticular formation is arranged in three longitudinal columns namely median, middle and lateral.

1. **Median (Figure 322):** It has ceratogenic raphae nuclei. It is placed in the periaqueductal grey. The stimulation which abolishes pain for several hours (Analgesia).

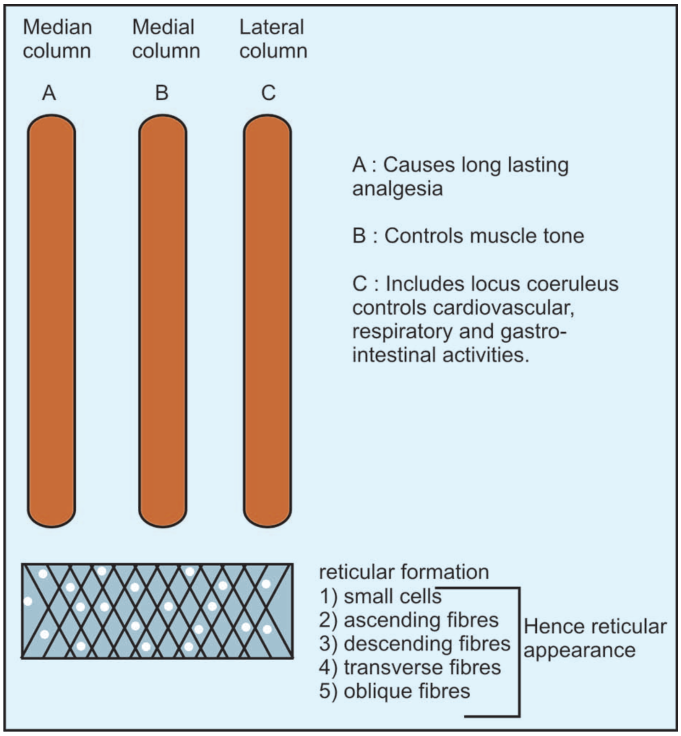



**Figure 322** Showing main three columns of reticular formation

2. **Medial:** It has the centre for muscle tone and horizontal gaze in the pons near the nucleus of the 6th nerve.
3. **Lateral:** The lateral column contains locus cerelues, parabrachial nucleus, Kolicar fused nucleus. It controls cardiovascular respiratory and the gastro-intestinal system. Locus cereleus has nonadrenergic melanin containing neurons. It helps in increasing the speed of the reflex and is known as the attention centre. It induces Rem (sleep). It helps in alertness, respiratory centre, inspiratory and expiratory centers are in the medulla. Inspiratory centre is in the obex of the medulla. Brainstem respiratory centres maintains automatic breathing in sleep.

In case of its destruction, pyramidal tract maintains the respiration, when the patient is awake. However if the patient sleeps he dies for want of automatic centre. It is known as Ondine's curse.

**Ascending Reticular Activating System (ARAS):** It contains reticular formation, trigemino-thalamic, spino-thalamic, gustatory and auditory tracts. ARAS is responsible for awakening and sleep. ARAS stimulates the cerebral cortex which gets alerted and as it suppresses the sleep. Smelling salt stimulates ARAS and patient awakes. Largactil, barbiturates and general anaesthetic agents like ether and penthathol suppress ARAS and induces sleep.

**Clinical:**

1. Petit mal type of epilepsy occurs due to the disturbance in the reticular formation.
2. Narcoplexy : induces sleep.
3. Cataplexy : causes paroxismal, muscular weakness during anger and laughter.

## Connections of Reticular Formation

**Afferent Connections:** From cortex, spinal cord, vestibular nucleus, acaustic nucleus, cerebellum, visual, thalamic, subthalamic, hypothalamic, corpus striatum and limbic system.

**Efferent Connections:** Spinal cord, brainstem, cerebellum, red nucleus, substantia nigra, tectum, thalamus, subthalamus, hypothalamus, corpus striatum and limbic system.

**Functions:**

1. Somatomotor
2. Somatosensory
3. Somatovisceral
4. Neuroendocrinal
5. Biological rhythm
6. Sleep arousal consciousness,
7. Perception
8. Reward, award and emotions.

# SURFACE MARKING OF HEAD, NECK AND FACE

## Parotid Gland

**Anterior Border:** A point on upper border of mandibular condyle.
A point slightly above the center of masseter muscle.
A point 2 cm below and behind the angle of mandible.

**Upper Border:** With concavity above across the ear lobule by joining the following points.
Upper border of mandibular condyle mastoid process.

**Posterior Border:** Straight line drawn across the tip of mastoid process.
A point 2 cm below and behind angle of the mandible.

**Parotid Duct:** A point at the lower border of concha of ear.
Another point midway between the ala of the nose and the red margin of upper lip. Parotid duct is represented by middle 3rd of a line joining these points.

**Superior Sagittal Sinus:** A point on the glabella, which is a median elevation of the forehead where superior ciliary arches of both sides meet.

**A Point on Inion:** Draw a line joining these points so that the line should be narrow in front and about 1.25 cm wide behind at the inion.

**Sigmoid Sinus:** A point on the asterion.
A point 1.25 cm above the tip of mastoid process.
Join these points by two lines 1.25 cm apart.

**Trigeminal Ganglion:** 4 to 5 cm deep to the pre-auricular point.

## Thyroid Gland

**Isthmus:** A point 1 cm below the arch of cricoid cartilage. Draw a horizontal line through it 1.5 cms across the trachea.

Take a point 1.25 cm below the previous one and draw a horizontal line through it 1.5 cm long.

These lines represent the upper and lower border of isthmus respectively.

**Lateral Lobes:** A point 1 cm below the lateral end of lower border of isthmus.
A point 1.25 cms lateral to the previous one.

Put a point on the anterior border of sternocleidomastoid muscle at the level of laryngeal prominence. It represents the upper pole. Join first two points with convexity below. This is lower pole of thyroid glands.

Join the point for upper pole with the lateral ends of upper border of isthmus and another with lateral end of lower pole.

**Internal Jugular Vein:** A point on the lobule of the ear.
A point on the sternal end of clavicle.

Join these points by a broad band of double lines make a dilatation at its lower end between the sternal and clavicular heads of sternocleidomastoid to represent the inferior bulb.

## Common Carotid Artery

| | |
|---|---|
| **Right Side:** | A point on the sternoclavicular joint<br>A point on anterior border of sternocleidomastoid at the level of upper border of thyroid cartilage. |
| **Left Side:** | Take a 3rd point in addition to the upper two slightly to the left of the middle of manubrium sterni, i.e. midway between suprasternal nautch and sternomanubrial joint.<br>Join these points by a broad band or double lines which represents the artery. |
| **Accessory Nerve (XIth):** | A point below and infront of the tragus.<br>A point on the tip of transverse process of atlas.<br>A point on the anterior border of sternocleidomastoid at the junction of upper 1/3rd and lower 2/3rd of the muscle.<br>A point on the middle of the posterior border of the sternocleidomastoid.<br>A point on the anterior border of the trapezius about 5 cm above the clavicle.<br>Join these points which represents the nerve. |
| **Subclavian Artery:** | A point on the sternoclavicular joint.<br>A point on the middle of the lower border of clavicle.<br>A point about 2 cm above the clavicle midway between the upper two points.<br>For left side put an additional point slightly to the left of the middle of manubrium sterni.<br>Join these points by a curved double line. |
| **Facial Artery:** | A point on the mandible at the antero-inferior angle of the masseteor where the pulsations of the artery can be felt.<br>A point about 1.25 cm lateral to the angle of the mouth.<br>A point at the medial angle of the eye.<br>Join these poinst by a wavy line which should pass forwards almost to the ala of the nose. |

# CLINICAL PICTURES

## Cysts

**Figure 327** Showing thyro-glossal cyst

**Figure 328** Showing goitre

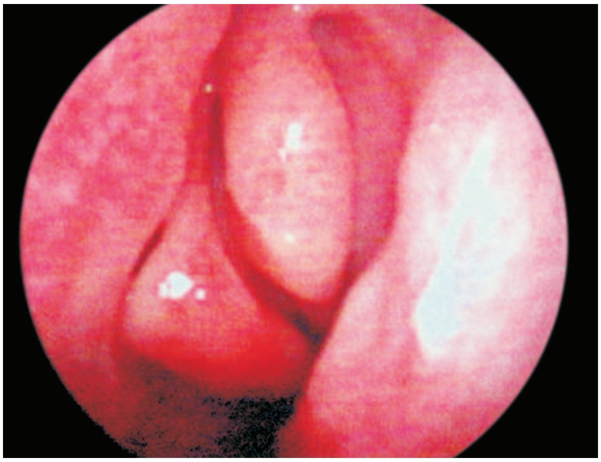


**Figure 329** Showing nasoscopy

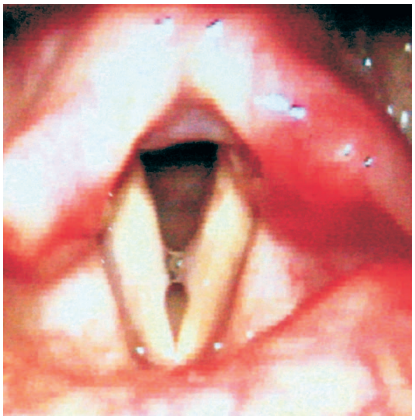


**Figure 330** Showing laryngoscopic view of vocal cord

**Figure 331** Showing cancer of tongue

**Figure 332** Showing hydrocephalus

# Brain Abcesses

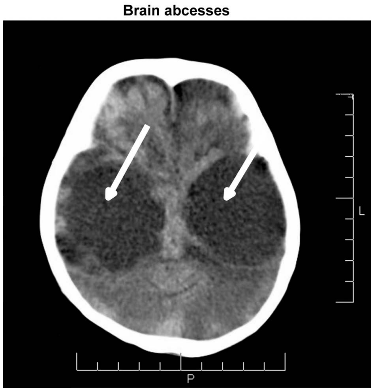



**Figure 333** Plain CT axial study well defined hypodense areas in both parieto-temporal regions

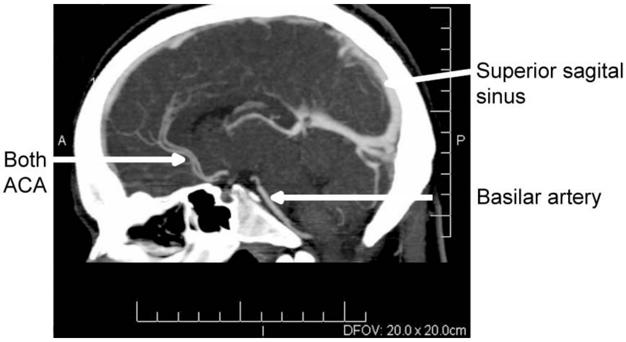



**Figure 334** Cerebral angiography


**Figure 335** Angiogram showing giant internal carotid artery aneurysm

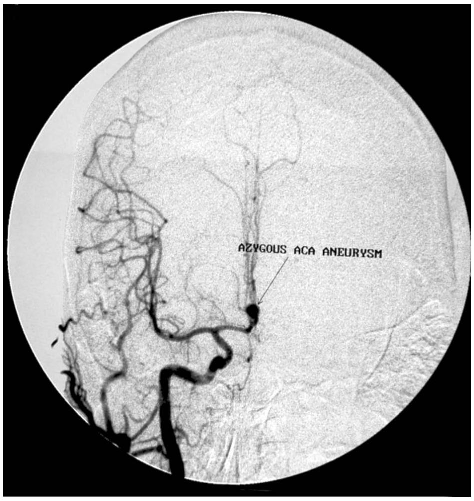



**Figure 336** Angiogram showing aneurysm of azygos anterior cerebral artery

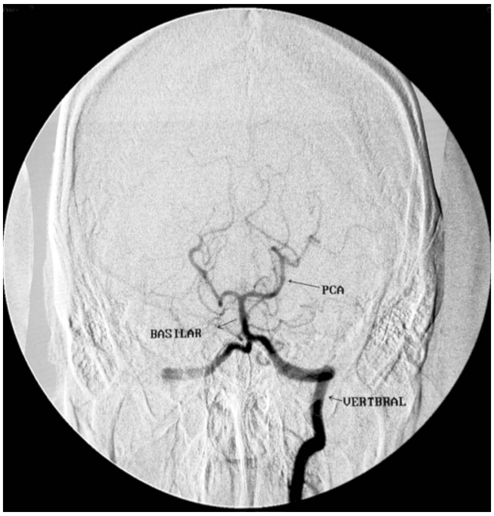



**Figure 337** Angiogram showing vetebral, basilar and posterior cerebral arteries

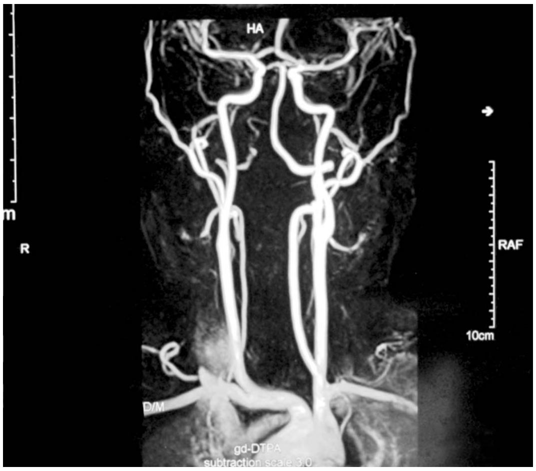



**Figure 338** CT angiography of carotids

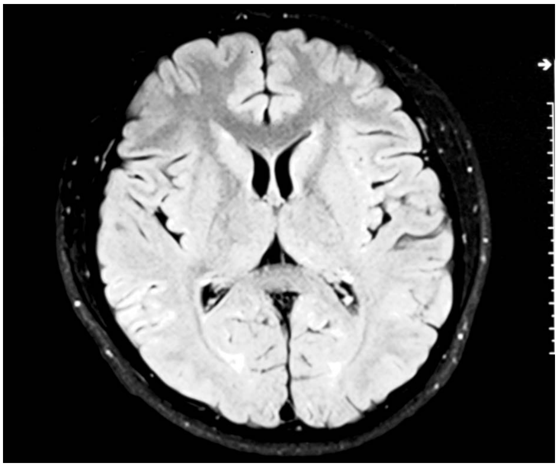


**Figure 339** CT brain

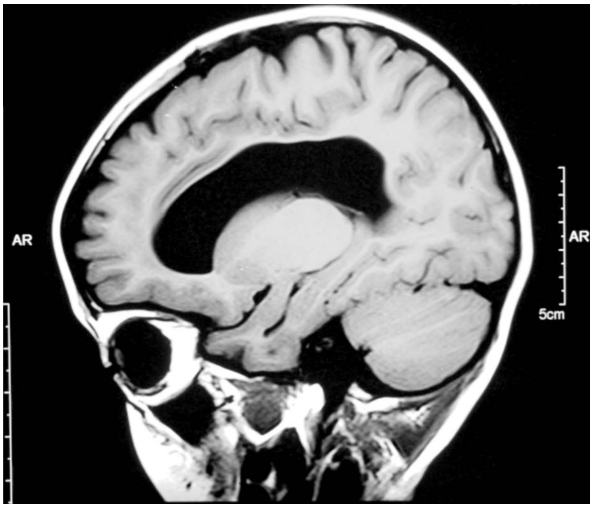



**Figure 340** Dilated lateral ventricle

**Figure 341** Cleft lip

**Figure 342** Cleft palate

**Figure 343** Carcinoma penis

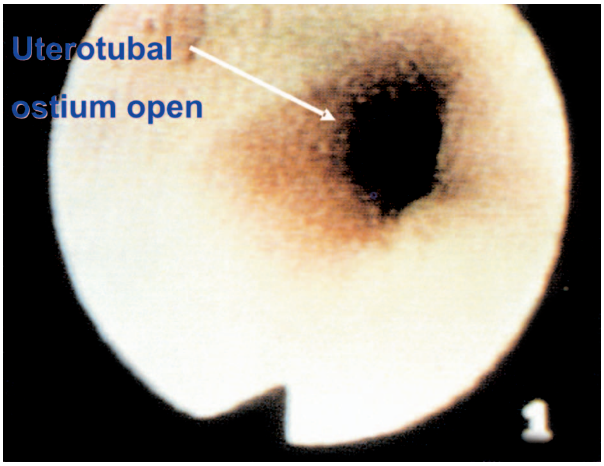



**Figure 344** Mixed parotid tumour

# INDEX

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## J



## K

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## Q



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## S